THE JOURNAL OF PROSTHETIC DENTISTRY

Official Publication of
THE ACADEMY OF DENTURE PROSTHETICS
THE AMERICAN DENTURE SOCIETY
THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS
THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY

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THE JOURNAL OF PROSTHETIC DENTISTRY

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EDITORIAL

THE JOURNAL OF PROSTHETIC DENTISTRY is seeing the light of day for the first time with this issue. Its period of gestation has been rather longer than was expected, so this issue includes Numbers 1 and 2 of Volume I. The prospects for the future indicate more regularity in the development of the numbers which will follow. Barring unforseen circumstances, there will be no more twins.

Leaders in the field of prosthetics have seen the need for a journal which would collect all the material related to this specialty. They have hoped for an outlet for *all* ideas, theories, and practices, which would develop a more thorough understanding of the problems of prosthetics. General practitioners of dentistry have looked for guidance from the specialists in the solution of their problems. Until today, there has been no adequate outlet for the specialist and his ideas. Until today, there has been no single source of information on the cross-section thinking in the field of prosthetics. The excellent papers which are read at the meetings of the prosthetic specialty groups, and at other dental meetings, need not be lost with their presentation.

The objective of THE JOURNAL OF PROSTHETIC DENTISTRY is to provide a medium for the interchange of ideas between those who are interested in advancing the knowledge of prosthetic restorations. All ideas and viewpoints will be presented, so the reader can judge their relative merits for himself. It is through this fair and unbiased analysis that the truth is learned.

The Academy of Denture Prosthetics, the American Denture Society, and the Pacific Coast Society of Prosthodontists are three leading prosthetic organizations in the world. Each organization has objectives and requirements for membership which are different from the others. (See pp. 3, 7, and 9.) Each is fulfilling its obligations in its own way, and is understandably proud of this responsibility. The common responsibility of all three groups is the study of prosthetic problems and the dissemination of information regarding it. This fact brought them together for the purpose of sponsoring THE JOURNAL OF PROSTHETIC DENTISTRY.

The very birth of the JOURNAL is evidence of the sincere interest which the entire membership of the three prosthetic organizations has in finding the truth, and in passing it along to others. Each of these organizations has had publication committees. Until now, these committees have been able to collect and distribute

to the members of their groups only a small portion of the material which was presented at their meetings. Now, all of this valuable material can be made available to the entire dental profession. This youngster has quite a load to carry.

The inspiration for the founding of THE JOURNAL OF PROSTHETIC DENTISTRY came from the patriarchs of dentistry who also have inspired the prosthetic leaders of today. It is impossible to name all of these early leaders here but the names of Bonwill, Snow, Gysi, Williams, Prothero, Wilson, Hight, Lane, Giffin, Price, Monson, and many others come to mind at once. Their unselfishness has set the pattern for those who follow them. John Geller, of the American Denture Society, Jack Werner, of the Academy of Denture Prosthetics, and Wilfred Terrell, of the Pacific Coast Society of Prosthodontists, had this inspiration. As Presidents of these respective organizations, last year, they urged their publication committees to found the JOURNAL.

The publication committees of the three organizations had this inspiration. Emil H. Bollwerk, Louis S. Block, and Emmett Beckley of the American Denture Society, Roland Fisher, W. Les Warburton, and George Hughes of the Pacific Coast Society of Prosthodontists, Thomas E. J. Shanahan, Raymond J. Nagle, and Claud J. Stansbery of the Academy of Denture Prosthetics were the representatives who worked out the details of the agreements between the three organizations, and with The C. V. Mosby Company. The cooperation and ethical attitude of The C. V. Mosby Company have been most gratifying.

The appearance of the JOURNAL in your hands is a tribute to these men and a recognition of their high ideals in and for dentistry. If you like the child, and the way it grows, credit should be given to its progenitors.

—Carl O. Boucher

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ORIGIN AND HISTORY OF THE ACADEMY OF DENTURE PROSTHETICS

I. Lester Furnas

La Jolla, Calif.

NO worth-while organization is organized spontaneously. The usual modus operandi is for a small group of farsighted individuals with common interests to meet on some occasion and talk, plan, and wish for a formal organized group where kindred souls may meet and discuss matters of mutual concern. Such indeed was the organization plan of The Academy of Denture Prosthetics. Just who was the first man to supply the necessary spark is not too definite, but it seems quite likely that this honor should go to either Dr. George Henry Wilson or Dr. Weston A. Price, both of Cleveland, Ohio.

The subject of Prosthetic Dentistry for many years might almost be described as dormant because very little was done to develop its scientific aspects until about the turn of the century. Physiologic and anatomic problems then began to arise, leading to confusion in what had been accepted as functional facts, and men interested in the subject began to question and investigate vigorously.

Prosthetic dentistry was not the only branch of the profession that was undergoing a radical revamping. Operative dentistry was having its troubles as well, and it was only natural that the two should combine and from their united efforts produce at least an aid to their dilemma. This was the organization of the National Dental Association Research Institute in Cleveland, Ohio, in 1913 under the direction of the National Dental Association Research Commission with Dr. Weston A. Price of Cleveland presiding.

Dr. Price was keenly aware of the situation and lost no time in seeing that developments in the field of prosthetics received equal attention with other branches of the profession. In this he was most ably assisted by Dr. George H. Wilson of Cleveland and Dr. William A. Giffin of Detroit, Mich. These men held many conferences and it is generally conceded that the birth of the idea of a prosthetic organization was one of the many profitable results.

It was about this time, and largely through the efforts of Dr. Wilson, that another man prominent in the prosthetic field became interested in the forming of a prosthetic research organization; this, of course, was Dr. Milus M. House of Indianapolis, Ind. Dr. Wilson made many trips to Indianapolis to discuss the matter with Dr. House, and in turn Dr. House spent all available time with Dr. Wilson in Cleveland. Talking and planning continued at every possible opportunity, and at each visit more was accomplished; thus, a basic pattern came into being.

During the warm evening of Aug. 3, 1918, Dr. House and I were attending the annual meeting of the National Dental Association in Chicago, Ill. At the time

we were staying at the Congress Hotel. A telephone call came for Dr. House from Dr. Wilson of Cleveland saying that he would like to come to the room to talk with him. In a short time Dr. Wilson arrived, and he and Dr. House at once started a most serious conversation regarding organizational plans for a prosthetic society. Each agreed that the time element was perfect, with practically every prosthodontist of note being available there in Chicago at the convention. One of these men soon called Dr. Giffin, who was also registered in the hotel and who quickly came to the room and participated in the discussion.

At a meeting the next day, the following men were present: Drs. G. H. Wilson, B. F. Theilen, M. M. House, A. Patterson, and I. L. Furnas. Dr. Giffin was absent because of important committee meetings in connection with the National Dental Association. It was mutually agreed that a dinner meeting should be held in the Congress Hotel, Chicago, during the midday of Aug. 6, 1918. A list of names was prepared with each man present to contact as many as possible, spreading the invitation by word of mouth to all who were known to be interested in prosthetic dentistry.

Of the 49 men on the list, 31 were present at the meeting on August 6. There was much enthusiasm at this meeting. A temporary organization was formed with Dr. Dayton Dunbar Campbell named as Chairman and Dr. Alex Patterson appointed as secretary. I find the whole record of what followed so well and accurately compiled in the minutes of the meeting that I quote directly from this source:

"The Chairman called upon our worthy senior, Dr. George H. Wilson, to lead the discussion and give his views concerning the proposed organization and to outline the purposes and possible usefulness of such a body. This was done in a most satisfactory manner and in addition to this each member gave hearty approval of the movement.

"The Chairman was then empowered to appoint a committee to select a name for the organization and to draw up a Constitution and By-Laws. Those named to serve on this committee were: Dr. George H. Wilson, ex officio, Dr. W. A. Giffin, chairman, Dr. S. H. McAfee, Dr. M. M. House, Dr. E. H. Mauk, Dr. R. W. Tench."

On August 9, Chairman D. D. Campbell called the group together and proceeded with official business, with Dr. Russell W. Tench acting as secretary.

Needless to say the organization gained momentum almost at once. As the project began to unfold, the enthusiasm began to grow. It was uppermost in the mind of every man interested in prosthetics at that historic meeting.

Committee reports were received and accepted tentatively. The following officers were nominated and elected, each by a unanimous vote:

Dr. George H. Wilson, Honorary President
Dr. William A. Giffin, President
Dr. M. M. House, First vice-president
Dr. Alex Patterson, Second vice-president
Dr. Payton D. Campbell, Secretary
Dr. Russell W. Tench, Treasurer

Those present at this meeting were elected charter members.

A good-will motion to make Drs. George B. Snow and J. Leon Williams honorary members of the organization was then introduced. Needless to say, these worthy gentlemen were honored at once. It was next moved and seconded that the Executive Council, as provided for in the tentatively accepted Constitution and By-Laws, be composed of the following men:

For one year: Drs. Abraham Hoffman and S. H. McAfee

For two years: Drs. Claud J. Stansbery and W. E. Cummer

It may seem strange that the Organization could attain such stature and growth without a name, but I assure you that this was by no means the case. Since the very first meeting this subject had been constantly discussed, both publicly and privately. Many different names were proposed and discussed such as: The Prosthetic Club, The American Denture Club, The Prosthetic Denture Society, The American Full Denture Society—a name later adopted by another prosthetic organization but rejected by this group because of its limiting the work to full dentures. It was the hope of some to expand the activities of this Society to include partial denture problems at some future date.

After much discussion, with everyone making his own suggestions, Dr. Wilson finally came forth with The National Society of Denture Prosthetists. True, it was a tongue twister, and true also is the fact that some of its most loyal charter members never did learn to pronounce the name correctly—some to this day insist upon saying "Pros-thet'-ists" instead of "Pros'-the-tists"—but that did not matter; it was adopted unanimously immediately, and for convenience was just as promptly shortened to N.S.D.P.

This group of letters will always have a sacred meaning to a small group of men. It was, you can understand, with no small heartfelt pain that, in 1940, some of the now "Old Timers" sat back and saw a total "outsider," a man who never had been and never expected to become a member of the Organization, induce the members to change the name because in his opinion it did not fit the Greek origin or something of the kind. He may have been correct, but he turned down the lights for a small group of men when he put his idea across with the membership at large and made of us not a Society but an Academy of which we were not members but Fellows.

The annual meetings of the Academy have always been of a high order. Programs have been well planned. Practically every man in the dental profession who has developed outstanding contributions in the prosthetic field has at some time taken an active part.

At times the Academy has been criticized by some members of the profession at large because of its failure to adopt and recommend certain denture techniques, basic principles, and theoretical ideas, most of which have been of a controversial nature. This is not and never has been the intended function of the Academy. All theories, principles, techniques, and materials have at all times been carefully studied by the Academy, and an honest attempt has been made to clarify, to the greatest legree possible, every controversial matter. This has been done to the extent where intelligent men, knowing the facts, may be

competent to choose for themselves that which might seem most practical in their hands. The Academy is, and always has been, an organization developed for scientific research and investigation in prosthetic problems in the field of artificial dentures; the personal advancement of individual Fellows has been, is, and will be entirely a secondary matter.

In closing this historic sketch of the founding of the Academy, it must be emphasized that a long book would be necessary to do it full justice. Perhaps this brief summary may have caught some of the vitality, the sincerity, and perhaps a little of the ingenuity and friendliness so characteristic of the Academy itself; if so, the objective of these lines will have been attained in full.

928 Silverado Street,
La Jolla, Calif.

Officers of The Academy of Denture Prosthetics, 1950-1951

President	Carl O. Boucher, Columbus, Ohio
President-elect	Raymond J. Nagle, Boston, Mass.
Vice-President	Ralph Boos, Minneapolis, Minn.
Secretary-treasurer	I. Lester Furnas, La Jolla, Calif.

THE AMERICAN DENTURE SOCIETY

HAROLD L. HARRIS, B.A., D.D.S.

Denver, Colo.

IN 1928, during the convention of the American Dental Association held that year in Minneapolis, Minn., a group of men gathered together to initiate the formation of a new organization in dentistry. The new group chose the name, The American Full Denture Society, and the following year, 1929, held its first annual meeting in Washington, D.C. The late Dr. Ralph Christy of Denver, Colo., was elected the first president of the Society.

The purpose of the Society was to give the average practitioner who was interested in full denture prosthesis an opportunity to learn latest procedures in a concentrated two- or three-day program, and to have closer contact with the essayists and clinicians for questions and answers and intimate discussion of personal problems.

Many dentists sought membership in the Society, but the new organization hardly had time to get its feet on the ground before the great depression of the early thirties caused its membership to dwindle to a mere handful of men. Yet, in spite of untold handicaps the annual meeting was held each year on the Saturday and Sunday previous to the opening of the annual session of the American Dental Association. At times the situation seemed too discouraging for the officers to carry on, and in those early thirties more than once the question came up whether or not the struggle should be continued. But somehow, some way, the Society weathered the storm, and by 1940 it was again an organization of over one hundred members, and enthusiasm and appreciation was widespread.

Then came World War II. During the years 1942 to 1946, in cooperation with the wishes of our Government that travel be curtailed as much as possible, no annual meetings were held. Nevertheless, the rising reputation of the Society caused men everywhere to seek membership, so that by 1947, when the annual meeting was resumed in Boston, the Society was stronger in every way than at any time in its short but eventful history. At this meeting in Boston the name of the organization was changed to The American Denture Society.

Today, The American Denture Society is one of the great organizations of dentistry with an inspiring membership of over six hundred practicing dentists, representing nearly all the forty-eight states, Hawaii, Canada, and Mexico. It is proud of the contributions made by many of its members to the thinking, to the daily application of practical procedures, and to the happiness of men practicing prosthodontics.

The American Denture Society is equally proud of the part it has played in conceiving, establishing, and making possible THE JOURNAL OF PROSTHETIC DENTISTRY. This JOURNAL fills a long-felt need for an additional outlet for the

vast amount of information available in the field of Prosthodontics. The Society is grateful to its hard-working Publications Committee, Dr. Emil Bollwerk, St. Louis, Mo., Dr. Emmett Beckley, Kansas City, Mo., and Dr. Louis S. Block, Louisville, Ky., for their untiring efforts in all the preliminary work essential to the introduction of a journal of this kind.

The American Denture Society stands squarely behind the Editor of the JOURNAL. Dr. Carl Boucher is thoroughly trained and capable, both as a practitioner and a teacher of prosthodontics, well-read, broad-minded, honest, and nonpartisan in his views. Under his guidance and editorship, the prosthodontic-minded members of the dental profession will have unlimited confidence in their new publication.

I believe the launching of this new JOURNAL OF PROSTHETIC DENTISTRY is another milestone in the progress of our profession, and, coincidentally, in the progress of The American Denture Society toward fulfilling its objectives. I quote from our Constitution: "The objects of this Society shall be for the promotion and advancement of Prosthetic Dentistry in its various phases; to be of assistance to those who are seeking this class of oral reconstruction; to cooperate with other Dental organizations; to promote harmony in the specialized branches of dentistry; to encourage research work among our members; and to be ever alert to the scientific development of Full Denture Procedure."

1325 E. 16TH AVENUE
DENVER, COLO.

OFFICERS OF THE AMERICAN DENTURE SOCIETY, 1950-1951

President ..... Harold L Harris, Denver, Colo.

President-elect ... John R. Wallace, Winchester, Mass.

Vice-president ..... Chester Perry, Detroit, Mich.

Secretary-treasurer ..... Arthur Roberts, Aurora, Ill.

HISTORY OF THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS

E. Leslie Eames, D.D.S.

Los Angeles, Calif.

THERE came into being on the Pacific Coast, in 1926, The Pacific Coast Dental Conference. The components of this Conference included the state dental associations of all states west of the Rocky Mountains, also the Provinces of British Columbia and Alberta, Canada. These components meet in conference every three years.

At the second meeting of the Conference in San Francisco, July, 1929, a small group of members whose interests were in dental prosthesis attended a lecture given by Dr. Russell W. Tench of New York City. The thought came to them that a prosthodontists' society on the Coast would do much to advance the skill of its members and the quality of service rendered in this important branch of dentistry. A canvass was made among those present at the Conference who were known to be interested in dental prosthesis. They met at luncheon the following day. Those present were Drs. Fred E. Gulick and David T. Chase of Portland; Frank E. Wood of Seattle; J. W. Martin and Wilfrid H. Terrell of Pasadena; James L. Howard of Hollywood; Milus M. House of Whittier, Calif.; J. Ray Gill of San Francisco, and E. Leslie Eames of Los Angeles. Dr. Tench attended in an advisory capacity. As a result of this meeting, The Pacific Coast Society of Prosthodontists came into being. Dr. Gulick was asked to serve as first president and prepare for the first meeting.

The first meeting was held in San Francisco early in the year of 1930. President Gulick had a most successful and enthusiastic meeting. The following men were in attendance and became the charter members of the Society: Drs. Fred E. Gulick, David T. Chase, Saul C. Robinson, and Everett M. Hurd of Portland; Frank E. Wood of Seattle; James Allen Graham, J. Ray Gill, Wm. A. Colburn, Wm. A. Beach, Frank H. McKevitt, and Thomas H. Forde of San Francisco; E. H. Mauk of Berkeley; Milus M. House of Whittier; James L. Howard of Hollywood; J. W. Martin and Wilfrid Terrell of Pasadena, and E. Leslie Eames of Los Angeles.

At the business session of the first meeting the following officers were elected: E. Leslie Eames, President; Frank E. Wood, President-elect; Thomas H. Forde, Vice-president and Wilfrid H. Terrell, Secretary-treasurer.

The second meeting was held July 4 and 5, 1932, at the Empress Hotel, Victoria, B. C. This meeting was well attended and many new members were added to the roster. Officers elected to guide the destiny of this new organization for the next two years were: Frank E. Wood, President; Thomas H. Forde, President-elect; Frank McKevitt, Vice-president, and Wilfrid H. Terrell, Secretary-treasurer.

The third meeting was held at the Cliff Hotel, San Francisco, April 3 and 4, 1934. This completes the early history. From this date forward, the Society has met annually until 1941. Meetings were omitted during World War II but were resumed annually after the close of the war.

Qualification of membership is high. Each applicant must present an essay or clinic covering original research. The membership is limited to fifty. There are now forty-eight active members who are striving to live up to the highest precepts of their organization and feel that "Those who serve best progress most."

The roster to date includes the following names: Drs. Arthur E. Aull, Chas. S. Ballard, C. H. Blanchard, James W. Carson, George H. Chiles, W. W. Cloyd, E. Leslie Eames, L. A. Edger, E. E. Eggleston, Roland D. Fisher, Donald A. Forsblade, Glenn B. Garrett, J. R. Gill, Fred E. Gulick, Wm. P. Harrison, Milus M. House, James L. Howard, George A. Hughes, Leroy E. Knowles, E. R. Kibler, Charles Lipp, I. B. Lynk, F. W. McCormick (Honorary), George McGee, Leon Marshall, Arthur C. Meigs, Earl Pound, Carl Regli, Saul C. Robinson, Ralph M. Rogers, Arthur W. Schultz, George A. Selleck, Paul R. Shenefield, Mark Skiff, C. N. Skinner, G. F. Steffan, Jr., Arthur W. Spaulding, Jerome Strain, W. H. Terrell, Morris J. Thompson, R. I. Vanderwall, W. Les Warburton, S. Edmund West, Jack Werner, Frank E. Wood, G. Newell Wood, Willoughby Wright, and Robert C. Zeisz.

The objectives of The Pacific Coast Society of Prosthodontists are directed toward the advancement of that particular branch of dentistry known as full and partial denture restorations.

Included in the discussions of this Society by its members and guests are the results of investigations and research in the field of denture base materials of all kinds. They consider their chemical and physical properties, their tolerance by the tissues of the mouth, various methods of forming these substances into their desired masses, and the action and reaction of these masses before, during, and after the forming process.

This Society is fortunate in counting among its members a group of men internationally known for their scientific studies, which they generously share, in dental and facial anatomy. The hard and soft tissues are given miscroscopic and macroscopic consideration by these men. Several of the members are originators of mechanical articulators which are recognized and used by colleges and practising dentists universally. Consideration and discussion of these devices is part of the Society activity.

Articulation, tooth design, comparative tooth efficiency, and nutrition are just a few of the further investigations carried on by the members and presented for consideration by this Society with the constant hope that something will be revealed that will be of benefit to the general practitioner of dentistry who may not have the desire nor the facilities to carry on such studies, and who still must be ready to render full and partial denture services to mankind and, most of all, that mankind may be better served.

715 Pacific Mutual Building
Los Angeles, Calif.

Officers of The Pacific Coast Society of Prosthodontists

President . . . . . Roland D. Fisher, Glendale, Calif.

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Vice-president . . . . . Clawson N. Skinner, Whittier, Calif.

Secretary-treasurer . . . Arthur W. Spaulding, Los Angeles, Calif.

GUEST EDITORIAL

PROBLEM SOLVING

ANTHROPOLOGISTS believe that our remote ancestors wished for the known good things of life as we do today, and also that they had as much intelligence as we have. But they met with less success because their techniques for problem solving were crude.

MAGIC

At one time men sought to solve their problems mostly by means of magic. If they wanted rain, they resorted to incantations; if they wanted good crops, they slaughtered animals or human beings with what they thought to be appropriate ceremonies; if they wanted to harm certain persons, they mutilated their effigies; if they wanted to avert plagues or cure diseases, they resorted to charms. The basic pattern was followed generation after generation without success. Even so, men continued to believe that physical laws were thus controlled. And, of course, the magician had a vested interest in magic.

ARISTOTLE

Rather late in human existence there arose a small group of original thinkers who challenged magic as a means of solving problems. The ancient Greeks, among whom Aristotle was the most outstanding, developed techniques so much better that men said: "This is it." Unfortunately, our thinking thus became so deeply channelized that most of us are still in the groove.

Aristotle with his "either or" and his syllogisms, and Euclid with his Q.E.D., formalized problem solving so neatly that their techniques were scarcely challenged for two thousand years. What passed for so long as a sure way of finding the truth is now seen to be, in part, a matter of words about words.

AUTHORITY

In the Dark Ages, and partly as a further development of the Greek school, we tended more and more to accept the word of the authorities. It was a serious matter to doubt them. So long as this remained the prevailing attitude, progress was stalled. In fact, we went backwards.

GALILEO

The next advance in problem solving was to settle questions of fact by observation or experiment, or both together. About the sixteenth century a few restive men defied the authorities and established certain facts by means of physical

proofs. Outstanding in the development of this technique was Galileo. Up to this stage of thinking there was no chance of our producing the automobile, antibiotics, television, and hundreds of other developments present and future. In a sense, Galileo was the father of scientific method.

All of the sciences made spurts by adopting this better technique of problem solving. In astronomy, for example, the acient Egyptians made a start. Much later came Copernicus, then Kepler, then Newton—and each time some of us said: "This is it." But it never was and never is.

Newton's law of universal gravitation was supposed to be the last word, but along came Einstein in the manner of Galileo and went beyond Newton. There will be still others.

EMOTIONS

But even with all the improvement in problem solving, our emotions still get in the way. Yes, emotion can cripple the keenest of minds and thus delay progress. From magic to scientific method it stands by to trip us up.

If our egos or our pocketbooks are in danger, we can scarcely resist the power of emotion. If Jones has gained a following for the "Jones method" of denture construction, can he restrain his emotion when judging Smith's new and different method? If Brown has developed a complex articulator to cope with a given tooth form, how impartial will he be toward a different tooth form that needs no complex articulator?

SO WHAT?

Now what has all of this to do with our new JOURNAL OF PROSTHETIC DENTISTRY? Much.

The pages of this JOURNAL will reflect the problem-solving techniques of those who contribute papers for it and those who edit it. Our profession has pretty well passed the primitive stage of hocus pocus. We seldom invoke such things as astrology, luck, or "holding a good thought" in trying for technical success.

But how free are we from Aristotle's technique of solving problems by juggling words? How many of us will think we have settled a point of fact by citing authority? And how many of us may be swayed because we have a vested interest in some material, system, or machine?

To the degree that our contributors and editors remain aware of the hazards of magic, word-juggling, authority, and emotion, and to the degree that we develop better problem-solving techniques, will this JOURNAL be a power for progress.

—Victor H. Sears

THE DEVELOPMENTS IN THE OCCLUSAL PATTERNS OF ARTIFICIAL TEETH

I. R. HARDY, D.M.D

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IT is pertinent that we take into consideration important background material in considering this subject. Previous to 1913 when Dr. Alfred Gysi of Zurich, Switzerland, carved his anatomic teeth—the teeth which, in this country, were called the "Trubyte teeth," and which Gysi refers to as his "normal-bite teeth" artificial teeth were only approximately anatomic in form, or were, as Gysi[1] wrote in 1927 "... non-anatomical, had no definite cusp interdigitation, and could be set one way as well as another." The Trubyte teeth were developed by Gysi on the groundwork of research by himself and his study of previous research, which he freely acknowledges. They were carved to harmonize with a condylar inclination of 33 degrees from the horizontal, and a similar incisal guidance. They were widely accepted and used for many years, and still are the teeth of choice for many excellent prosthodontists.

"Artificial teeth can be properly formed only by application of the knowledge of the conditions under which they must function," wrote Gysi.[2] The normal-bite teeth did not function to his satisfaction in cases where alveolar resorption had so narrowed the maxillae in relation to the mandible that a cross-bite arrangement was necessary to prevent dislodgement of the denture bases. Gysi then proceeded to design a tooth especially for cross-bite cases, and I cite it because it was a definite departure from the almost universally accepted 33 degree normal-bite teeth. They were smaller teeth. The mandibular teeth were 33 per cent and the maxillary teeth 40 per cent smaller than the normal-bite teeth.

When I had the good fortune to be with Gysi for a short course of study in Zurich, in 1928, 60 per cent of the dentures constructed in the clinic were made with cross-bite teeth. In adjusting the occlusion of these teeth, the incisal guidance was set at 10 degrees. The incisal guidance was 33 degrees for the normal-bite teeth, so the resultant cuspal pitch on the adjusted cross-bite teeth was considerably diminished. The buccal cusp of the maxillary teeth in the cross-bite pattern was pretty much eliminated. Those who are familiar with the work of Brenner[3] or Payne[4] will recognize that the method of tooth arrangement they employ where they grind the buccal cusps of the maxillary teeth or tip them so they are free of occlusion, employing the lingual cusps of the maxillary bicuspids and molars only, has a precedent in this work of Gysi's. In fact, both Brenner and Payne emphasize the fact that one of the virtues of their method of tooth arrangement lies in the

The clinical research carried on in connection with this experiment was financed by research funds supplied by Austenal Laboratories, Inc., New York, N.Y.

Read before the Academy of Denture Prosthetics, Milwaukee, Wis., May, 1950, and before the American Denture Society, Atlantic City, N.J., October, 1950.

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fact that a mortar and pestle action takes place between the lingual cusps of the uppers and the troughlike depression on the lower teeth. Gysi mentions this mortar and pestle action as extremely important. As this paper progresses, you will observe that others disagree.

In 1928 Sears[5] introduced his "channel teeth." This, so far as I know, was the first of the so-called nonanatomic tooth forms, for the mandibular teeth, especially, bore no resemblance whatsoever to anatomic teeth. Gysi's cross-bite teeth were, it is true, a step in this direction, but Sears' approach was radical, and hence "viewed with alarm" in conservative circles.

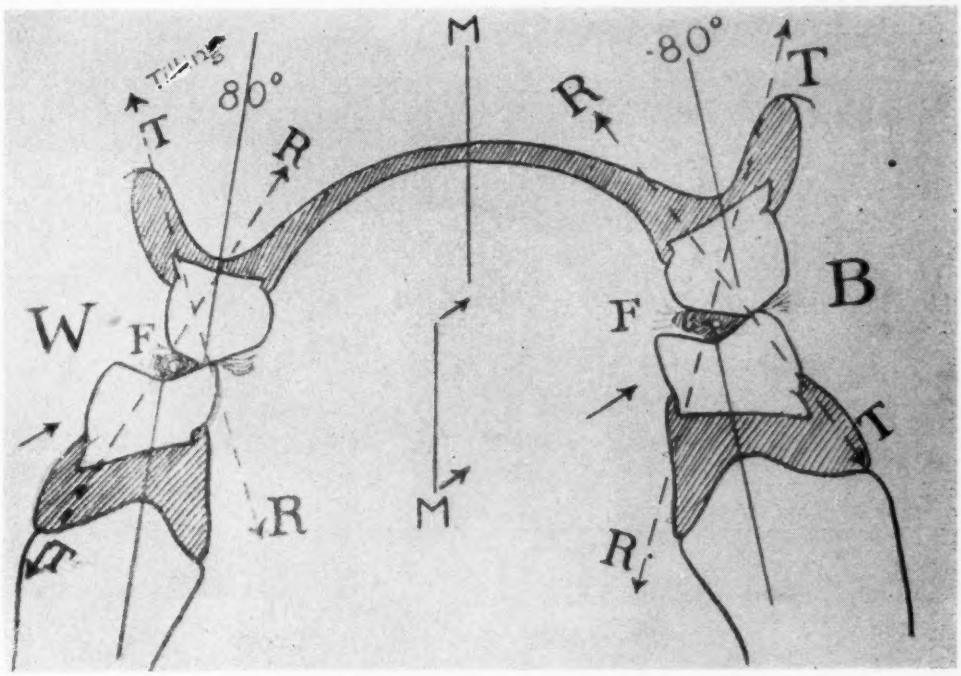


Fig. 1.—Gysi's design for cross-bite teeth, with buccal cusps of upper teeth eliminated. (Courtesy Dental Digest.)

Sears' maxillary teeth were shaped anatomically on the buccal aspect, but occlusally they were nonanatomic. Sears was highly critical of normal-bite teeth, and emphasized that his teeth were designed "for the efficient cutting of food"—no mention of any mortar and pestle or grinding action, you will note. Sears designed his teeth because he was concerned with the shifting of the denture bases caused by the use of anatomic artificial tooth forms. His aim was "to minimize the shifting of the denture base and hence guard against trauma and atrophy." Sears' maxillary teeth presented both a buccal and lingual plane, falling away from a central horizontal fossa, because, without such inclination, he says "it would be impossible to obtain balanced occlusion during function." The lower teeth were buccolingually less than one-half as wide as anatomic molds and the working occlusal portion, the only part making contact with the opposing upper teeth, was an unbroken ridge of

porcelain, 1 mm. to 1.5 mm. in width, running mesiodistally the entire length of the occlusal surface.

Sears' channel teeth are not now either made or marketed. Their design indicated some very original thinking, and their introduction required considerable courage on the part of their designer.

Sears[6], nearly ten years later, said: "The major objective of special occlusal forms is to prevent the appalling destruction of human tissue,—to preserve the integrity of the supporting ridges." In this article Sears advocates a wider working occlusal surface than his channel teeth possessed. He presented, about this time, a design called "Sears' platform posterior." These teeth were never made or marketed in any quantity, so far as I know.

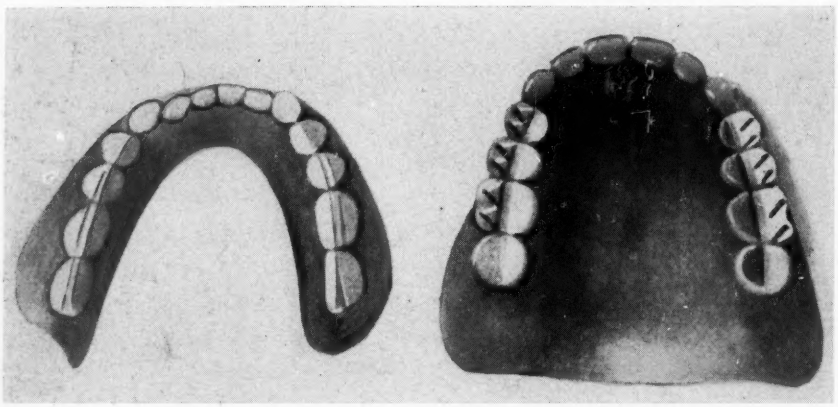


Fig. 2.—Sears' "channel tooth," with narrow cutting blade in lower teeth and cuspal pitch on upper teeth. (Courtesy Journal of the American Dental Association.)

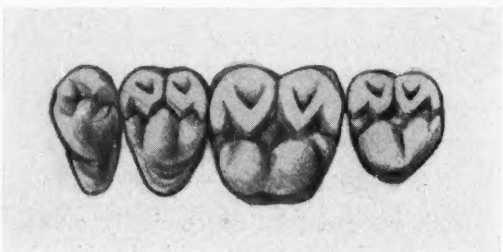
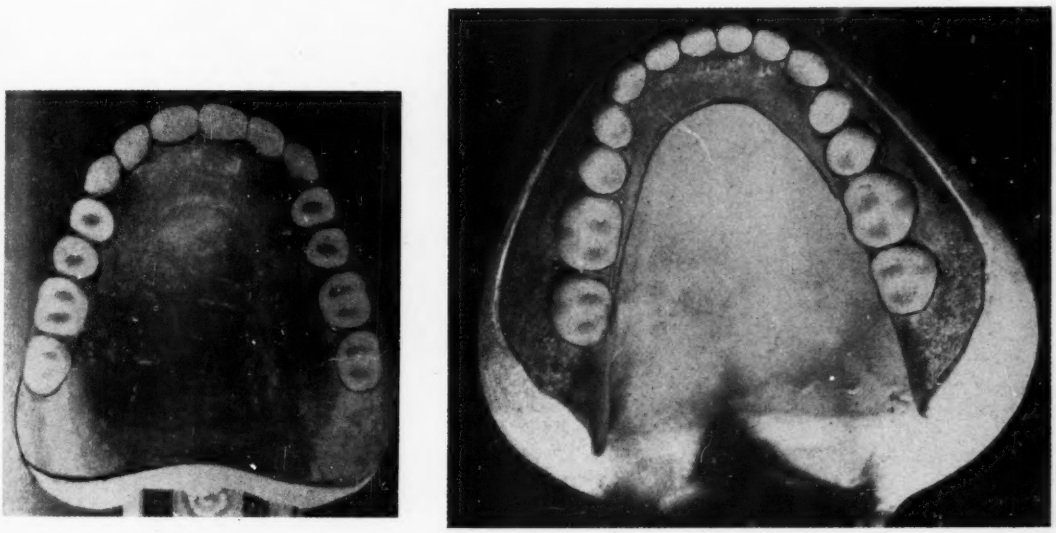


Fig. 3.—Sears' "platform teeth" with wider food platform than his channel teeth.

In 1929 Hall[7] introduced a nonanatomic form he called "inverted cusp" teeth. He criticized Sears' channel teeth as follows "The aim of these teeth is to free dentures of cusp-lock and interference in the antero-posterior relation and movements, and to anticipate and compensate for antero-posterior relational change between the dentures, as a result of settlement of the dentures. But the Channel tooth is still a cusp tooth. What are we going to do about cusp-lock and interference in lateral excursions?" So Hall formed his teeth with no cuspal pitch whatsoever. In designing them he was influenced, he says, by the design of a machine "for grinding wet or dry substances, employing the principle of two spaced revolving discs, rotating in opposite directions." This, he was informed, "is the best mechanical

principle yet devised in this line of endeavor. The opposing surfaces of the discs contain a multiplicity of cups, the peripheries of which form a series of cutting edges which intersect each other exactly like the occluded inverted cusp teeth. Centrifugal pressure forces the substances being ground into the machine, and in and out of the cups."

I think a valid criticism of Hall's design, is the fact that the action of the teeth is *not* analagous to the action of the machine. The centrifugal force which clears the cups of debris is not present in the mouth, and the lower cups tend to retain food. Once the cups are food packed they lose considerable efficiency. I do want to direct your attention to Hall's emphasis on the cutting and grinding, not the mortar and pestle action of his teeth. Hall's teeth are still made and marketed.



A. *B.*

Fig. 4.—Hall's "inverted cusp" teeth. (Courtesy Journal of the American Dental Association.)

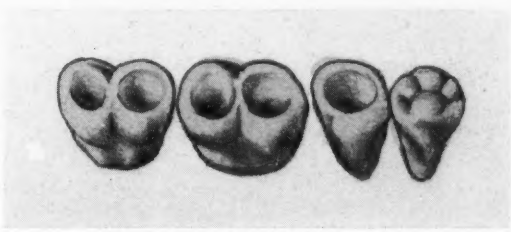


Fig. 5.—Sketch showing detail of Hall's teeth. (Detail in the original article [Fig. 4] being indistinct.)

Not long after Hall's teeth were introduced, Myerson brought out his "Tru-cusp" teeth. This tooth, so far as I know, is not described in American dental literature. It had no cuspal inclination; in other words, it was flat on the occlusal surface, with cutting blades and crushing tables incorporated in the occlusal carving. These teeth were of full occlusal width, unlike Sears' channel teeth. They also had some sluiceways carved in the areas adjacent to the cutting blades,

a desirable feature not present in Hall's teeth. Emphasis was placed, in the advertising, on their ability to both crush *and* cut foods. These teeth are now made and marketed.

French[8] in 1935, described a tooth of his design. He introduced it, he says, "because the logical inference is that anatomically formed molars do not meet the

Fig. 6.—Lower half, French's original carvings showing cuspal pitch on the upper teeth, and narrow lower teeth. Upper half, new carvings. (Courtesy Dental Items of Interest.)

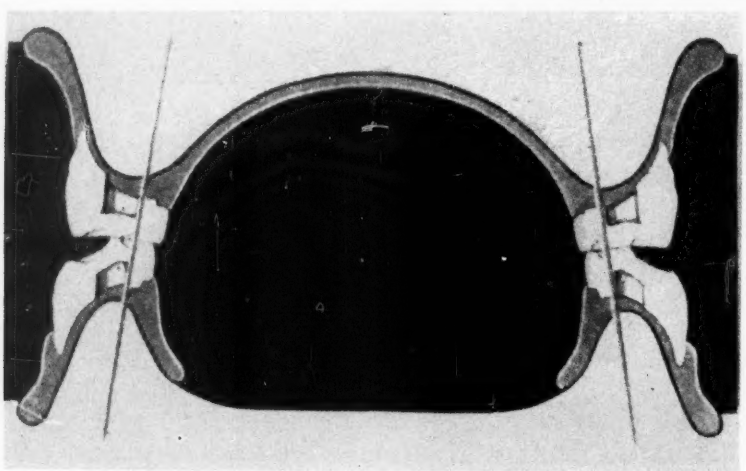


Fig. 7.—Flat occlusal surface of upper teeth in French's teeth as marketed at present. (Courtesy Dental Items of Interest.)

requirements of artificial dentures. They were designed to function under given conditions. In the case of artificial dentures these conditions no longer exist." French's teeth consisted of upper bicuspids and molars having buccolingual cuspal pitch, the width of the teeth being about the same as anatomically designed teeth.

The lower teeth were much narrower than the conventional pattern, but at the same time much wider than Sears' channel teeth. Sears' teeth had been criticized as having no food table, and that criticism was merited. French provided a food table on his mandibular teeth, but the food table was comparatively narrow, consisting of an area which on an anatomic tooth would be the lingual cusps. The area normally occupied by the buccal cusps was entirely eliminated, so the tooth was really about one-half a tooth in width. French reasoned that by eliminating the buccal half of the occlusal surface, greater stability of the denture bases was assured, a conclusion with which I heartily agree.

These teeth presented no anteroposterior cuspal interference or interlocking. In this, they were like Sears' which preceded them, and Swenson's which followed them. French's original carvings have been superceded by a different carving not made by French, which is considerably modified. The upper teeth are now nearly, if not entirely, devoid of cuspal pitch or inclination, and the lower teeth in over-all measurement are full width. However, the buccal half of the lower teeth form a surface which lies below the working occlusal level, leaving only the lingual half of the teeth in occlusal contact. These teeth are made and widely distributed today.

Fig. 8.—Swenson's "non-lock" teeth.

Quite some time after Hall's teeth were designed and made, and I believe after French's original carvings, Swenson,[9] at that time Professor of Prosthetic Dentistry at New York University College of Dentistry, designed a tooth in some ways like Hall's, but with these important differences. The teeth were provided with sluiceways for clearing food from the depressions between the cutting edges, and they had buccolingual pitch to provide balance. I do not find these teeth described in the literature, but there are illustrations of them in Swenson's excellent textbook. From conversation with Swenson, I can say that he designed these teeth to be food cutters, not crushers or millers; in fact, the cutting edges were so sharp as to be friable. Anteroposteriorly there was no cuspal inclination, so that the mandible was free to move forward without any interlocking of cusps. In fact, the tooth was called "non-lock." To my knowledge, it is not now made or marketed.

The Avery brothers[10] wrote in 1930: "A patient should be trained to use both sides at once, distribute the food over the whole chewing surface. It is a natural action and patients readily acquire it. Shearing should be the outstanding feature of the occlusal surfaces, rather than crushing or grinding, as shearing registers less pressure than any other means of food separation." I will go along with the Averys on the shearing action being an extremely important one. On the matter of distributing food equally on the whole chewing surface, this is a very difficult

trick and, if you don't believe it, just try it at your next meal. Most of you, in fact, I think all of you, will prefer to place the food bolus on the working side, "doin'," as Ethel Merman sings, "what comes naturally." The Averys' food distribution plan has, however, some support in Gysi's[11] writings in 1928. "Deglutition will not act automatically on food in the condition in which it is discharged from the working side of the mouth. Between the balancing facets on the balancing side, this partly masticated food is subjected to much lower rubbing and crushing movement than

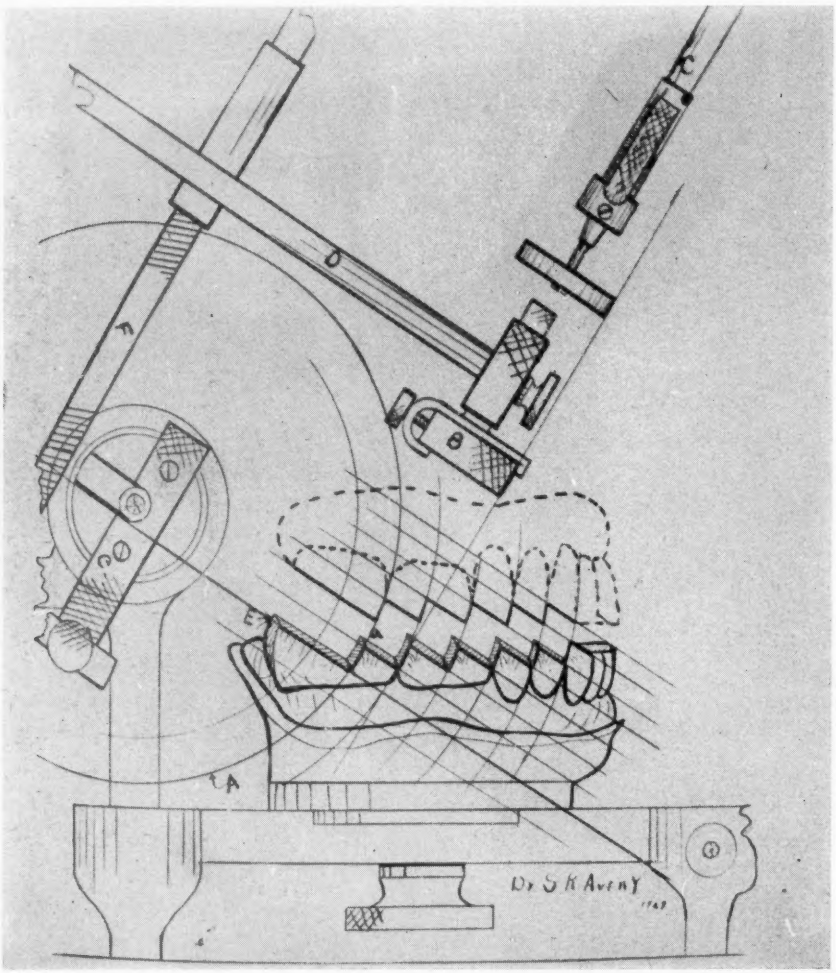


Fig. 9.—Avery's method of developing cusps which are free buccolingually, but interlock anteroposteriorly. (Courtesy Journal of the American Dental Association.)

on the masticating side. Here it is comminuted and insalivated to a condition which prepares it for automatic deglutition." This statement is highly questionable. Food which floats over to the balancing side could conceivably be subjected to a rubbing action. It will *not* be crushed.

The Avery teeth are interesting because they seek to solve the problem of efficiency in artificial teeth by having the teeth definitely interlock anterposteriorally, but free them of any cuspal inclines buccolingually. This was done to promote the

shearing principle to which they subscribe. I share their enthusiasm for shearing as an efficient food-shredding force, but most certainly do not subscribe to their method of securing it. So far as I know, the Averys did not market their teeth.

McGrane[12] in 1936, described a "curved cusp tooth constructed with curved grooves and curved cusps forming segments of an arc, concentrically arranged from a radial center corresponding to the right and left rotation centers in the heads of the condyles in the glenoid fossae." These curve grooves and cusps built from an arbitrary center may lead you to inquire, "Will the curvature be adaptable to cases measuring less than four inches?" The binding possibilities of this type of tooth placed on a case with a 3.5 inch radius is about 0.05 mm. McGrane gives

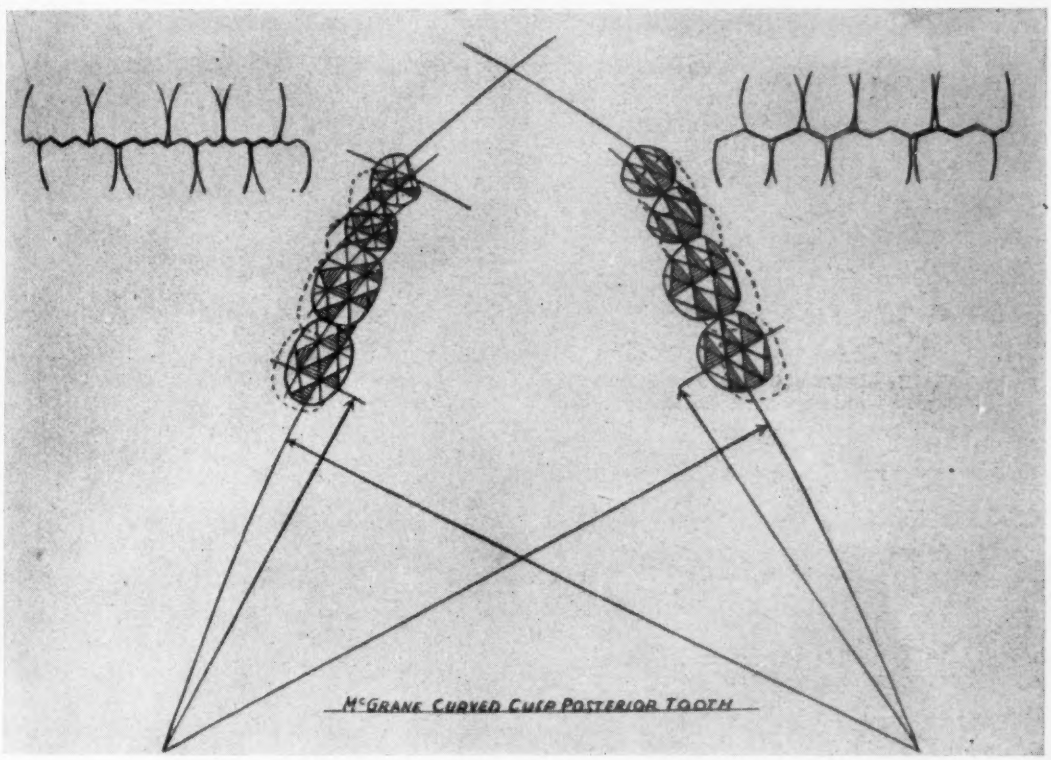


Fig. 10.—McGrane's principle of developing "teeth with carved cusps." (Courtesy Journal of the American Dental Association.)

no method for adjustment in cases where interference occurs. These teeth lock very definitely in anteroposterior relationship. The principle employed seems very much like that of the Averys. No attempt at balanced occlusion is made. McGrane further states that, "cusp teeth are necessary to provide the maximum amount of efficiency during mastication. The arrangement of opposing cusps should be to remove any possibility of trauma during function movement." I should think it might be quite a trick to set the McGrane teeth so there would be no possibility of trauma. The McGrane teeth are made and marketed currently.

Two other types of teeth, one of porcelain, called the "geometric" tooth, designed by LaDue and Saffir, and the "zero degree" posterior tooth of plastic

marketed by Justi would appear, from their design, to be better adapted for crushing than for cutting or shearing. Neither tooth is described in the literature.

Thompson,[13] in 1937, describes an interesting experiment in chewing efficiency of artificial teeth. He tested 33 degree cusp teeth, 20 degree teeth, Hall's teeth, and Sears' channel teeth. He found (briefly) that carefully balanced anatomic teeth, 33 degrees, gained highly in efficiency when the occlusal surfaces, after being ground to balance, were sculptured to restore the anatomic ridges. This is a procedure long advocated by Schuyler. It "sharpens" the teeth and makes better food cutters of them. Thompson's experiments showed that carrots were most difficult to chew, followed by lettuce, cabbage, cold boiled ham, celery, and apples.

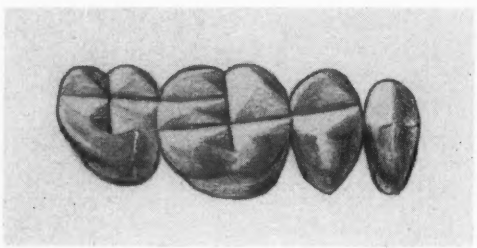


Fig. 11.

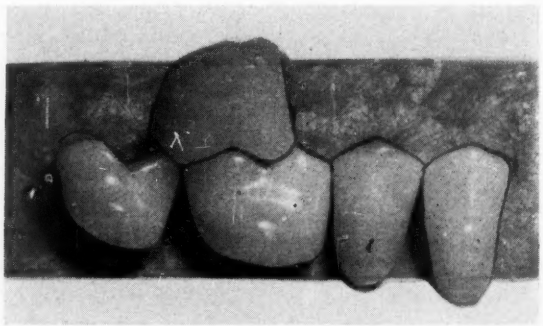


Fig. 12.

Fig. 11.—Detail of McGrane's teeth.
Fig. 12.—Anteroposterior intercuspation of McGrane's teeth.

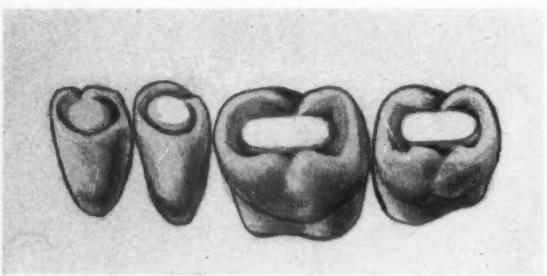


Fig. 13.

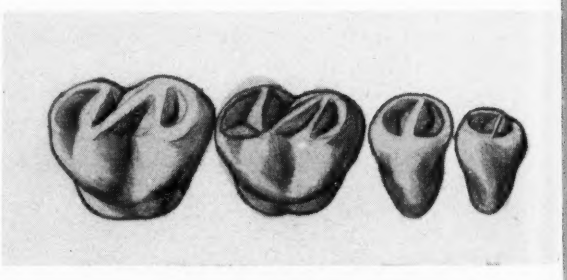


Fig. 14.

Fig. 13.—"Geometric" teeth, designed by LaDue and Saffir (a flat plane tooth).
Fig. 14.—Justi acrylic teeth (flat plane teeth).

In chewing tests of other than 33 degree teeth, the 20 degree teeth and Hall's teeth, showed almost the same degree of efficiency. Sears' channels were not so efficient. The 20 degree, Hall's, and Sears' teeth were tested by providing an ingenious method of mounting the different posterior teeth on the same set of dentures. This was an excellent piece of research work.

An unreported test of masticating efficiency was made in 1940 at the Houston Meeting of the Academy of Denture Prosthetics. A half dozen or more types of teeth were tested, and the teeth which proved most efficient on carrots (the only food tested) were French's teeth, which had been recut by Blanchard so that their

occlusal surfaces had sharp cutting blades running buccolingually on the lower teeth. This experiment involved the building of a set of dentures on duplicate casts, for every set of teeth tested—quite an undertaking. May I say that I have been influenced greatly in my thinking by this experiment.

Having given a very brief digest of what seemed to me to be the most pertinent writing on the subject of occlusal surface form, may I comment on my personal findings gleaned from the use of the teeth mentioned? May I say, too, that while many patients have expressed satisfaction with the artificial teeth made for them, and felt that they chewed their food efficiently, many others have complained that there were many foods that they could not manage with artificial teeth. This has always bothered me. I have been looking, for years, for teeth that would cut food efficiently, but which would do so with a minimum of shifting of the denture bases. Sears[14] said in 1928, "The wearer of artificial teeth should reconcile himself to the habit of avoiding all foods that require vigorous chewing." High as is my regard for Sears, I have never been reconciled to the acceptance of this dictum for denture wearers.

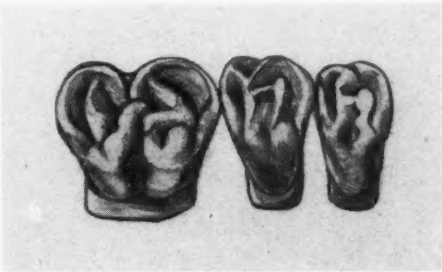


Fig. 15.—Teeth designed by the author. Flat plane teeth with sharply carved cutting blades and free sluicing.

I have used 33 degree teeth, Gysi cross-bite teeth, Sears' channel, Hall's inverted-cusp, Myerson tru-cusp, French's posteriors, and have even used combinations of the above, such as French's lower posteriors with Hall's or Myerson's uppers.[15] Then, about 1935, soon after the ideas of Fournet and Tuller and others advocating greater coverage of tissue in mandibular denture bases influenced me to do likewise, the original French's carvings I had been using became less useful to me. On the somewhat restricted area previously covered by the mandibular denture base, French's teeth seemed adequate but, on the wider base, patients complained of food packing into the buccal pouch.

Seeking to remedy, or at least alleviate this point of annoyance, I ground off the buccal cusps of 20 degree Trubyte teeth (full width teeth) refashioned the working linguo-occlusal surface into something like French's tooth, and reglazed the ground surface. These teeth helped considerably in the buccal food packing, since they had sufficient buccolingual over-all width, but I never could make them as efficient as I had hoped. So, in about 1939, I carved some teeth which were made in porcelain for me by Austenal Laboratories, Inc., which were flat occlusally, but which presented a series of cutting blades on the surface which were sharper, and at the same time more freely sluiced than any teeth I had ever seen. These teeth,

however, were so sharp that they were friable. I found out that porcelain cannot be carved to a really sharp cutting or shearing edge which will stand up under hard service.

A.

B.

Fig. 16.—Dentures made in 1946 with bent stainless steel cutting blade imbedded in acrylic. (The second set of dentures of this design.)

When methyl methacrylate plastic came into dentistry, this tooth I had made in porcelain was made in arcylic.[16] It was easy to reason that if the friability which had made the carving of really sharp teeth in porcelain impossible could be overcome, we really would have efficient artificial teeth. I have found that the teeth which I designed, when made in acrylic, have been very comfortable for patients to wear. They do, however, exhibit abrasion with a consequent dulling of the cutters, and they have not been as efficient as I would have liked to have had them.

In 1946, it was suggested to me that an acrylic tooth in which were imbedded metal cutting edges might make an efficient food shearing tooth. At that time, I constructed for a woman, 55 years of age, full upper and lower dentures employing this principle. The patient had worn an upper denture for some years. She had a lower denture made six years before, but had never worn it, because it was uncomfortable. Her upper ridges were good, her lower ridge was practically nonexistent. After three adjustments the new dentures were comfortably worn, and the late Dr. John O'Rourke, Dean of the Graduate-Post Graduate School of Tufts College Dental School, and I conducted chewing tests to see what we had. The patient could chew carrots as well or better than anyone I have ever seen perform with artificial teeth. Her score on celery, raw cabbage, and baked ham was also extremely high. In her case the metal shearing elements were inserted only in the second bicuspid and first molar. The patient, who was extremely intelligent and helpful in these tests, suggested than an additional shearing element in the first bicuspid region would be useful.

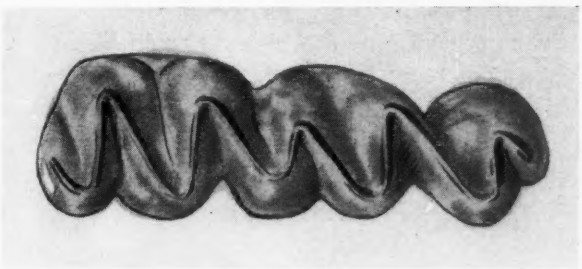


Fig. 17.

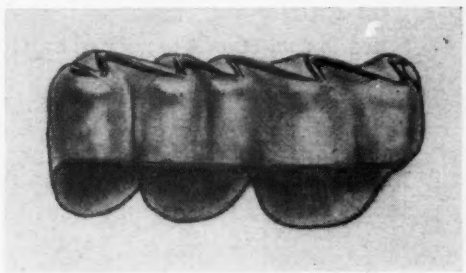


Fig. 18.

Fig. 17.—Occlusal detail of lower segment showing sharp cast cutting blades and free sluicing.

Fig. 18—Lingual view of lower segment showing acrylic carried high on lingual to protect tongue.

In August, 1947, a set of dentures were constructed for a man who had previously been wearing dentures, made in the School Clinic, which were comfortable but inefficient in mastication. In these replacement dentures the metal shearing blades were incorporated in both bicuspids as well as the first molar. After a short adjustment period chewing tests, using the same foods as the first patient tried, were instituted and the efficiency of the teeth amply demonstrated.

In both the dentures I have mentioned, the cutting blades were made of a stainless steel plate which was bent into a pattern. A casting of Vitallium of similar pattern to the bent one was now made and in March, 1948, dentures were made for a patient using this Vitallium pattern. The results were satisfactory.

In April, 1948, a set of dentures were made for a woman who had previously worn dentures which were unsatisfactory from the standpoint of mastication. With the new dentures she reported, with considerable satisfaction, that she could eat baked potato skins!

Altogether about 60 sets of full dentures with the metal inserts have been made for various patients, almost none of which were made on ridges which were of a favorable type. One set of these dentures was a complete failure. The patient was a dentist who had previously worn both porcelain and plastic teeth. With the porcelain teeth, his lower ridge was always sore; with plastic teeth, the soreness in the lower ridge showed considerable improvement; with the metal insert teeth, his lower ridge was again sore and uncomfortable, and he changed back to plastic teeth.

Another patient had worn both plastic and porcelain teeth, neither of which were comfortable; with metal insert teeth, he had great improvement in eating, and fried clams were his piece de résistance! He continued, however, to have some soreness in his lower ridge. He prefers to wear the metallic teeth, however, because of their greater efficiency in chewing.

In August, 1948, I constructed full dentures for a patient who came to me, not because she was having difficulty with the dentures she wore, but because they were esthetically unsatisfactory. I made dentures with metallic occlusion inserts for her to see whether or not they would be acceptable to her esthetically. They were entirely acceptable. After she had worn the dentures for a few weeks, I asked her whether she noticed any difference in the manner in which she could chew her food, and she said she did not notice any difference. After she had worn them for three months, one of the cuspids came off the upper denture and she had to leave the denture with me for repair; in the meantime she used her previous dentures. When she returned for the repaired dentures, she said, "My, I am glad to get these back! I realize now what a poor job of chewing I was doing with the old ones."

This patient and thirty or forty others were private patients who paid me substantial fees for their dentures. I mention this to emphasize the fact that an innovation of this kind seems to be acceptable to patients other than those in a clinic.

I made eight cases of full upper dentures (one an immediate denture), functioning against large partial lower dentures, using metallic occlusal inserts. These all functioned satisfactorily.

On the early dentures I made, I was very fearful lest the patients injure themselves by biting the tongue. This did not occur. There was one instance of tongue irritation on one of the early cases and this was eliminated by raising the plastic, which is molded around the inserts, high enough on the lingual to prevent the tongue making contact with the metal. This type of design, with the plastic high on the lingual, has been followed since the experience I had with this early case.

Sears[5] and Pleasure,[17] not in collaboration, but in independently written articles, have laid down specifications for posterior artificial teeth, which I have taken the liberty of combining. They specify that the teeth should be so designed that between centric and eccentric positions, there are no interfering projections to restrict mandibular movement. It should be possible to set them in cross-bite relationship if necessary. The working occlusal area lingually from the ridge crest should exceed 50 per cent of the total area (100 per cent is the ideal). One surface of the dental arch should be available to provide bilateral balance. Such balance should

be attained without sacrificing the ideal angle of any portion of the working occlusal surface. The bulk of the teeth should be sufficient on the lingual side to make satisfactory contact with the tongue, and on the buccal side to fill the vestibule. All working surfaces are to be substantially at right angles to the direction of closing force, and the area of the combined working surfaces is to be in proper proportion to the supporting value of the tissues. The teeth may be altered by grinding without losing their mechanical or esthetic advantages. The occlusal form permits compensation for change in ridge relation as a result of the tendency of the alveolar ridges

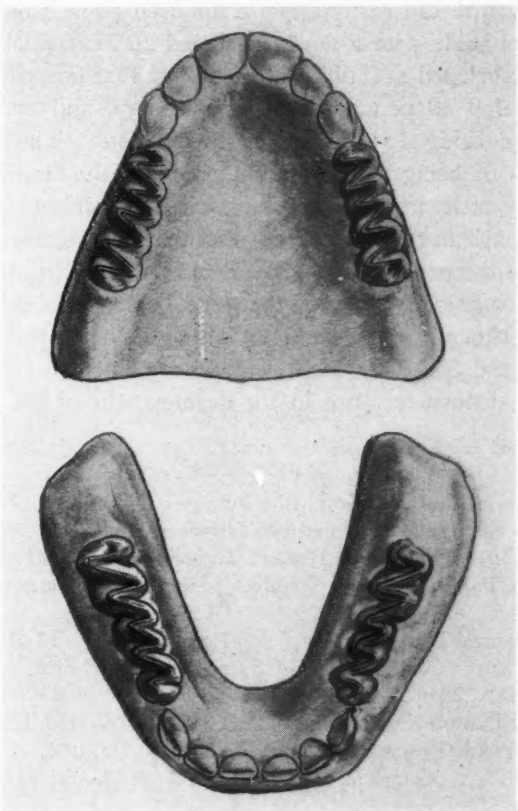


Fig. 19.—Occlusal view of upper and lower dentures showing shearing and cutting blades imbedded in acrylic, blades which are not friable, as in porcelain, or subject to dulling by wear, as are the plastics.

to atrophy. There are to be no wells or hollows in which food can pack. The relation of the opposing occlusal surfaces must not interfere with the arrangement of the anterior teeth for speech and esthetics, and any degree of horizontal overbite must be possible. The teeth must present the degree of cutting efficiency required to cut fibrous foods and hence diminish trauma.

The teeth I have described fulfill all the foregoing specifications at least reasonably well in all particulars and almost perfectly in many particulars. Let us consider the alteration of the teeth by grinding. Any considerable amount of

grinding, for occlusal adjustment, destroys the occlusal pattern, be it anatomic or otherwise. The metallic insert tooth can be ground as much as 2 mm. All that is necessary to restore it to its original sharpness and efficiency is to remove the acrylic between the cutting blades to the original depth below the occlusal surface. This can be quickly and easily accomplished.

Another extremely important point is cutting efficiency. I believe that these teeth shear and cut food better than any I have ever seen or used.

Artificial masticatory units should be designed to be much more efficient than the form nature provides, for they must function under working conditions which are unfavorable. Nature can easily apply a hundred pounds of biting pressure on natural teeth. Tests made with a newly designed and extremely sensitive electrognathodynometer, developed at Tufts College, show that few patients wearing artificial teeth can develop 30 pounds of biting pressure, and many develop only 5 pounds, the average being 15 pounds, or thereabouts. The denture wearer is under the handicap of being able to apply only greatly diminished biting force. Therefore, in theory at least, and in so far as it is possible to practice, his masticating units should have an efficiency three times that of Nature's.

These teeth are the product of a great deal of thought on the part of many of the men quoted, with some ingenuity on the part of myself and those who cooperated with me in this experiment. They could not have been made without the technologic advances in metals and plastics, which we have combined to create something that I believe may be a distinct advance in the development of the occlusal pattern in artificial teeth.

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DISCUSSION

Developments in the Occlusal Pattern of Artificial Teeth, by Irving R. Hardy, D.M.D.

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DR. Hardy's paper deals with a period in dentistry in which we have both been active participants, and it is with pleasure that I join him briefly in a discussion of nonanatomic posterior tooth forms.

The advent of new ideas very often inspires effusive reactions and I am sure that Dr. Hardy will agree with me when I say that this has been particularly true in dentistry when anyone has been bold enough to present, or even support, the idea that nonanatomic types of posterior tooth forms might better meet the requirements for artificial dentures than would the anatomic types.

Progress does not usually result from strict adherence to tradition. It is fortunate that in most groups there are a few individuals who are willing to assume the roll of pioneers in an attempt to improve upon widely accepted concepts regardless of the immediate reaction of their associates. This has been particularly true of such men as Dr. Victor Sears and others whom Hardy has mentioned.

It is my personal opinion that Sears made one of the really great contributions to dentistry when he brought out the "channel posterior" tooth, principally because of the influence which this tooth form had on our present day concepts of occlusion, both in natural and artificial dentures. These teeth provided specific areas for centric occlusion and other specific areas for the various eccentric occlusions, and their use led to the idea of applying similar concepts to all tooth occlusions. As a result we began to think in terms of selective occlusions and selective spot grinding in the correction of malocclusions, instead of the hit-and-miss methods which had previously been employed.

Why should we concern ourselves about the occlusal surface forms of artificial posterior teeth when nature has already given us posterior occlusal patterns which, in normal natural dentures, are admittedly superior in masticating efficiency to any artificial substitute which we could hope to devise?

The answer which I would give to this question would be influenced by the fact that the support which is provided to artificial denture bases by edentulous ridges is entirely different from that provided to natural dentures, and also by the fact that edentulous ridges undergo constant morphologic changes, whether or not artificial dentures are being worn. As prosthodontists, we are faced with the

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problem of constructing artificial substitutes for natural dentures which will best serve their intended purpose under conditions which are pre-established and usually very unfavorable.

When an engineer is called upon to design a machine to accomplish a specific purpose it is expected that he will also design or designate a foundation for the machine which will properly support its working parts in order that they may accomplish their intended purpose.

Nature did just that when she provided the human dental mechanism with very efficient masticatory units; she also provided a highly specialized type of support for each of these working units. If it were not for the fact that somewhere along the line there has been a break in Nature's plan, human beings would retain their natural teeth, and there would be no need for artificial dentures.

The human dental mechanism is actually a tripod in which the occluding dental arches constitute one leg and the temporomandibular joints the other two legs. In the presence of natural dentures the intercuspation of the teeth exerts a powerful influence upon jaw relationships, even to the extent of causing trauma of the temporomandibular joint in some cases of occlusal disharmony; but when the natural teeth are lost in one or both jaws it becomes advisable to accept the temporomandibular joints as the principal guiding factors if we are to minimize the shifting of artificial denture bases. Artificial dentures cannot and should not be expected to exert the same directing influence upon jaw relations as did the natural dentures.

Time will not permit elaborating upon this point here, but I recommend that ample time be devoted to the study of "The Nature of the Temporomandibular Joint as it Affects Artificial Denture Construction." In effect the temporomandibular joint is comparable to a mechanical joint in which the condyle rests against a resilient-like pad, while being maintained in this position by strong rubber bands, and with more or less freedom of movement in the horizontal plane. It is easy to visualize the multiplicity of changes, from the rest position of such a condyle, that would be possible when varying degres of strains are placed upon the condyle. Although such a comparison to the temporomandibular joint is to a degree an exaggeration, it does serve to indicate the nature of the guiding influences which are supplied to the mandibular ridge by two legs of the dental tripod in the absence of rigid guiding influences from the dental arches.

The centric occlusion of unaltered anatomic-type posterior teeth is comparable to a ball resting part way down in a conical-like cup. Such an occlusion is the equivalent of a point in space, and would result only when the approaching occlusal surfaces were directed by precision-like guidances. The human dental mechanism does not furnish such precise closing guidances to either natural or artificial teeth.

In the case of artificial dentures, especially, it is logical to assume that the use of occlusal patterns, which offered centric occlusion areas instead of centric occlusion points only, would result in less denture base movement on the edentulous

ridges. Clinical experience proves this assumption to be true, and no doubt accounts for the fact that a growing number of prosthodontists are using nonanatomic posterior tooth forms on artificial dentures.

It has been my experience that the use of certain nonanatomic posterior tooth patterns and arrangements have resulted in better denture base stability and comfort to the patient over a longer period of time than I have been able to obtain with conventional anatomic types.

Although many dentists adhere rigidly to the use of anatomic occlusal patterns, it has been my observation that many artificial dentures, in which anatomic type posteriors have been used, present posterior occlusal surfaces which are definitely nonanatomic in form by the time the dentures have been adjusted to the functional requirements of the patient.

All artificial dentures seem to function better when their posterior occlusal surfaces offer centric occlusion contacts which are not limited to one specific static jaw relation at a given vertical dimension. Unaltered anatomic posterior teeth do not meet this requirement. It would, however, be a comparatively simple matter for tooth manufacturers to improve the present anatomic types, in this regard, with a very slight alteration of their manufacturing molds.

I have stressed the centric occlusion feature of artificial teeth because, and I believe that most prosthodontists will agree with me, the majority of full denture patients develop the habit of depending primarily upon centric occlusion for the mastication of food. This is, no doubt, due to the fact that, in most cases at least, they experience less denture base movement in the centric occlusion range.

We should, therefore, plan the centric occlusion of artificial teeth so that it offers areas instead of limited point contacts, while at the same time offering a reasonable degree of masticatory efficiency in the centric occlusion range of the artificial dentures. In addition to this function, artificial occlusal patterns should contribute to denture base stability and retention, as well as contribute to the favorable distribution of forces which result from masticatory function. In this regard I have found that a slight modification of the general principles of artificial denture occlusion as advocated by Pleasure, Bosweli, and Kurth to be very advantageous, not only because it contributes to mandibular base stability and retention, but also because it tends to direct functional masticatory forces onto those areas of the mandibular ridge which seem best able to receive and resist them.

I am glad to find that Hardy's posteriors are applicable to this type of occlusion. Although Hardy's posteriors are a bold departure from conventional concepts, they do seem to offer many desirable features. They not only provide a wide range of centric occlusion contact but they also offer a high degree of masticating efficiency within this area, with a minimum of closing force being required.

I have not as yet used Hardy's posteriors on practical cases, but I expect to do so as soon as they are available in the desired shades and molds. I was glad to note that Hardy made special reference to the possibility of tongue irritation from these teeth. I would suggest that he keep the cutting blades a sufficient

distance from the lingual surfaces of the teeth to guarantee against future exposure of the cutting blades in the lingual area as would occur from the wearing away of the plastic material in this area.

Those of us who have used plastic posterior teeth know that they do wear away quite rapidly in some mouths. This wear would, of course, be advantageous in the areas between the cutting blades because it would tend to improve their cutting efficiency, as occurs with the incisors of rodents. It would not be desirable in the lingual areas because of the possibility of future tongue irritation. This is especially true in the mouths of those patients who do not return to the prosthodontist for periodical examinations, as all artificial denture wearers should.

It has been my observation and experience that we dentists are prone to theorize new ideas out of existence, so far as we are concerned at least, but I have learned that this is a very poor policy. We must not forget that, according to theory alone, the bumble bee positively cannot fly, but I am sure that there are those of us who can testify to the fact that he actually does so with very impressive efficiency.

Clinical experience still remains one of our best sources of information regarding new ideas. The best of artificial dentures are actually the result of many compromises, but compromises which have been made in the most favorable directions. Let us, therefore, as members of the American Denture Society, assume the roll of researchers, in the interests of the patients whom we are privileged to serve.

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FULL DENTURE SERVICE AS INFLUENCED BY TOOTH FORMS AND MATERIALS

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IN discussing the efficiency of various tooth forms and materials, we must possess a common understanding of standards or values of denture service: what an efficient denture service means to the patient, and what the denture patient should expect from the prosthetists.

Prosthodontia may justly be classified as a health measure equal to any other specialized service rendered by members of the dental or medical professions. Systemic evidences of dietary and vitamin deficiencies are commonly associated with the need of efficient denture service. Continued oral discomfort may seriously affect the general nervous system resulting in neurosis or impaired function of any organ of the body. The need for efficient denture service may seriously influence one's personality, resulting in self-consciousness, an inferiority complex, reduced acumen, and a desire to seek solitude. It may cause one to become irritable and morose. It may seriously impair one's employability.

The dentist in rendering a prosthetic service is not merely inserting a mechanical device for which the patient may develop tolerance. He is treating a physical defect. His treatment may be simplified to a degree; it cannot, however, be standardized. His treatment must be planned and coordinated to meet physical needs of the patient.

In answer to what the denture patient should expect from the dentist, we might list, in what seems to be their relative importance, comfort, maintenance of oral tissue health, ridge stability, efficiency in the function of mastication, clarity of speech, and favorable esthetics. Our discussion will be limited to posterior teeth; therefore, little consideration will be given to speech and esthetics, as these factors are influenced to a lesser degree by the selection of posterior tooth forms and materials.

With few exceptions, the prosthodontist of today recognizes the necessity of minimizing horizontal stresses as one of the most important factors in the maintenance of oral health and ridge stability, with its favorable influence upon oral comfort, and the period of time during which dentures may serve a useful and efficient purpose. Horizontal stresses are influenced primarily by the steepness of guiding tooth inclines; therefore, our problem would seem to resolve itself into the selection of that tooth form with limited lateral inclines which would serve most efficiently in the mastication of food, with a limited application of force, or the modification of existing anatomic forms to meet these needs.

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In studying this problem, we must have an understanding of the factors controlling the inclines of posterior occluding tooth surfaces. The human articulating mechanism is similar to a tripod with two extreme posterior controlling factors (the temporomandibular joints) and one anterior controlling factor, the lingual incline of the upper anterior teeth commonly spoken of as the incisal guidance. In the temporomandibular joint, we have the anterior movement of the condyle head on the incline of the articulating eminence and the Bennett or lateral movement of the condyle head in the glenoid fossa, and unlimited intermediate movements. The incline of the articulating eminence of the glenoid fossae and the incisal guidance control all normal protrusive mandibular movements while teeth are in contact. The extreme controls of the lateral or masticating movement are the Bennett or lateral movement of the condyle head on one side, the anterior incline of the glenoid fossa on the opposite side, and the incisal or cuspid guidance. For functional harmony in all lateral positions, all posterior occluding tooth inclines, regardless of make or form, must harmonize with these three extreme guiding factors. All intermediate movements are controlled in a similar manner.

In lateral functional positions, as in the act of mastication, there are functional or masticating tooth inclines on the one side, and balancing tooth inclines on the opposite side. The functional tooth inclines are controlled by and must harmonize with the lateral incline of the glenoid fossa or Bennett movement and incisal guidance. At the same time the inclines of the teeth on the balancing sides are controlled by and must harmonize with the anterior incline of the glenoid fossa and the incisal guidance.

The incisal guidance, due to its proximity, controls to a greater degree the steepness of the occlusal inclines of posterior teeth than does the lateral or anterior inclines of the glenoid fossa.

In the natural dentition, an overly steep incisal guidance which prevents normal functional contact of posterior teeth in eccentric positions may have an undesirable, if not pathologic, influence upon the Bennett movement. This may cause the condyle head to move in a backward or upward direction, or a backward and upward direction, while it might normally move in a more nearly lateral and horizontal direction. In the artificial denture, an overly steep incisal guidance, out of harmony with posterior tooth inclines, seldom contributes to temporomandibular joint pathology, but it is a most detrimental factor in denture stability, functional efficiency, and health of supporting structures. A steep incisal guidance is always contraindicated because, for functional harmony, it necessitates steep posterior tooth inclines which unquestionably contribute to rapid alveolar resorption.

In the construction of artificial dentures, the inclines of the glenoid fossa must be recognized, but the incisal guidance is an independent factor and may be modified at the prosthetist's discretion. The lack of steepness of the incisal guidance in no way influences the normal movements of the condyle heads in the glenoid fossae. Therefore, it is logical to reduce the incisal guidance insofar as esthetics will permit. Only by the reduction of the incisal guidance is it possible to make the desirable

reduction of occluding inclines of all posterior teeth, thereby favorably controlling destructive horizontal stresses. If the incisal guidance and Bennett movement are horizontal, the occluding inclines of posterior teeth on the working side will be horizontal and stresses will be directed in a vertical direction favorable to ridge support. The balancing inclines on the opposite side, being controlled by the incisal guidance and anterior incline of the glenoid fossae, will be a composite of those factors. The balancing incline of a second molar, commonly midway between the incisal guidance and the glenoid fossae, would be approximately one-half the incline of the glenoid fossae, if the incisal guidance was horizontal.

Glenoid fossae and incisal guidances, not tooth forms, control horizontal stresses. The factors of tooth inclines and directional stresses are identical, regardless of whether anatomic tooth forms, cuspless teeth, channel teeth, or the Pleasure plan of occlusion are used, when condylar and incisal guidances are the same, and when eccentric occlusal contacts exist on both functional and balancing sides. Denture stability, in so far as it is influenced by cusp incline, is no more favorable with one tooth form than with another. The incisal guidance is the only controlling factor which may be increased or decreased at the discretion of the prosthetist. This factor, and not the use of nonanatomic versus anatomic forms, is the prosthodontist's control to horizontal stresses.

Denture stability may be favorably influenced by the careful selection of incisal guidance. Those favoring the Pleasure plan of occlusion speak of its stabilizing effect upon a lower denture with unfavorable ridge support. The Hall plan of occlusion may be favorably used in the prognathous case, where we commonly have the undersized and unfavorable maxillary ridge. In the first instance, teeth are most often related with a shallow but positive incisal guidance. In the second case, a negative incisal guidance is often used. One tooth form may be more readily adapted to a desired incisal guidance but, again, it is the selection of the favorable incisal guidance that enables us to arrange posterior teeth and, if necessary, modify their form in a manner to give favorable denture stability.

When unfavorable ridge relations exist, the selection of favorable tooth forms may facilitate the arrangement of the teeth in relation to ridge support. As an example, the Hall cuspless tooth may be readily arranged in a cross-bite relationship, or the channel teeth may enable the prosthetist to set the lower posterior teeth lingual to the normal position, due to the absence of the lower lingual cusp, without restricting tongue space and function.

Experience with the various tooth forms has led me to believe that more favorable balancing contacts in all eccentric relations can be obtained with an anatomic tooth form than with the cuspless or channel tooth form. The nonanatomic forms depend primarily upon the curve of Spee, or upon position of the second molar to obtain eccentric balancing contacts, while with the anatomic form eccentric contacts can be maintained upon the cusp inclines of each individual tooth, thus distributing the balancing contacts over a broader area.

McLean has aptly said many times, "Traumatic occlusion—antagonism between opposing teeth—lies not in the cusp per se, but in the misplacement and in-

correct angulation of cusps; the solution lies not in removing the cusps, but in properly placing and coordinating them."

Much has been said about the unfavorable denture stability developed progressively with the settling of the dentures, due to loss of alveolar support when anatomic tooth forms are used, comparing them unfavorably with cuspless and channel teeth. This is true when the anatomic form teeth are arranged with a steep incisal guidance, but it is not true when they are modified and balanced with the same favorable incisal guidance as would be used with the cuspless or channel teeth. In fact, the problem has seemed to be more difficult with cuspless or channel teeth, premature contacts developing on the last molars progressively with loss of vertical dimension when depending primarily upon the curve of Spee to maintain balance rather than the cusp inclines of each tooth.

The masticating efficiency of anatomic teeth can be seriously impaired or greatly improved while reducing cusp inclines and perfecting a balanced relationship. Neither a balanced relationship nor functional efficiency can be achieved by the indiscriminate use of abrasive pastes. A careful study of natural tooth anatomy enables us to visualize certain tooth cusps as cutting surfaces which function upon opposing tooth inclines, the steepness of which are coordinated with condylar and incisal guidances. By selective spot grinding, the cutting efficiency of the original cutting cusp is maintained and, with slight modification, the cutting efficiency of these cusps can be greatly increased.

Nature provided us with many favorable features in the anatomic tooth, which are factors in increased masticating efficiency. She provided us with double cutting cusps which shear as the mandible passes from eccentric toward the centric, finally functioning as mashers as the centric relationship is approached. The occlusal surfaces of the lower teeth also function as a favorable table upon which food is held by the cheek and tongue for mastication. Favorable food exits and minimal contacting surfaces avoid functional trauma.

Schultz,[1] by careful research, has estimated that approximately 32 per cent of the masticating efficiency of the anatomic tooth is lost when the lingual cusp is out of eccentric functional contact. The channel tooth has only one cutting cusp with limited mashing facilities and a very narrow food table. The Pleasure tooth, due to lack of cutting cusp sharpness, has limited cutting efficiency. The cuspless tooth has reasonable shearing, but little mashing efficiency. When the teeth have been materially ground, they lose their cutting efficiency. There would, therefore, appear to be no question of the comparative masticating efficiency of these nonanatomic teeth with that of the properly modified anatomic tooth form. Most research on tooth form and masticating efficiency has verified these facts.

PLASTIC TEETH

There seems to be only one thing in favor of the plastic tooth over the porcelain tooth, while there are many disadvantages. The wearer of the plastic tooth, in a few instances, is less disturbed with troublesome clicking noises. This, however, is normally controlled by a vertical dimension, which is not excessive, and well-

adapted denture bases, and by harmony of occlusion in centric and eccentric positions. We are told that the softness of the teeth protects the mucosa. This is fictitious. The rapidity of wear seriously affects vertical dimension, tooth relationship, and masticating efficiency. This wear results in increased horizontal stresses and associated sequel.

It has been said that the rapidity of wear results in a reduction of occlusal disharmony and associated trauma. It should be readily recognized that any mechanism, improperly constructed, with parts not properly assembled and coordinated will not wear into functional efficiency. Excessive wear of teeth, as any other mechanism, produces loss of mechanical coordination and functional efficiency. In the denture, it means also loss of vertical dimension and jaw relationship.

CONCLUSIONS

In conclusion, it is, therefore, extremely difficult to visualize a greater degree of oral comfort, functional efficiency, or a longer period of usefulness with dentures made using any one of the many nonanatomic tooth forms than by the use of the anatomic tooth modified and arranged to a functional balance using the same favorable incisal guidance as would be used with the nonanatomic tooth, with the possible exception of the case with unusual ridge relation which necessitates a cross-bite or other abnormal positioning of teeth. Of the present-day materials, the porcelain tooth, while possessing structural weakness, seems to most adequately meet the functional requirements in rendering a prosthetic service.

It would seem that a great service might be rendered by the tooth manufacturers to the denture-wearing public and the dental profession if they would market an anatomic posterior porcelain tooth with greatly reduced cusp inclines which might be arranged and coordinated with a horizontal incisal guidance without excessive and time-consuming modifications by the prosthetist.

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COMFORT AND CHEWING EFFICIENCY IN DENTURES

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COMPLETE denture prosthesis in this century has become a problem of major concern in dentistry. Each decade has brought an increase in the life span of human beings and with it increased denture usage and problems. Today more people die of diseases associated with old age because more people live long enough to acquire them. The manifestations of degenerative and deficiency diseases usually become more apparent and also increase in severity with the age of the patients. In dentistry the manifestations of degenerative and deficiency diseases are usually irreversible in action, biologically speaking, and are, therefore, with us as problems as long as the patient lives.

Emotional disturbances are often the basic cause for the breakdown of the body, including the oral structures, and in many cases are, themselves, the result of systemic disorders. In either event they manifest themselves in oral complications and become denture problems to the prosthodontist.

The prognosis of a case is influenced very materially by biologic aspects of systemic and local nature particular to each case. Patients come to us in varying degrees of health and age with the resultant complications and effects evidenced in their oral health because, logically too, many patients who wear dentures have lost their teeth as a result of systemic disorders. Osteoporosis, resorption, hypersensitiveness of tissues, gagging, and many other conditions with systemic backgrounds evidenced in the oral cavity act as a barometer of the health of the patient and contribute unfavorably to the final result in denture prosthesis.

To achieve chewing efficiency and comfort in the restoration of the edentulous mouth is a mechanical project, governed and guided by the physiologic and biologic factors peculiar to each patient. While the technique may be a mechanical interpretation of the fundamental principles in restoring the masticatory organ, yet comfort and chewing efficiency are to a degree dependent upon the compromises made in the technique to adapt it to the individual conditions and factors as they present themselves.

We realize that esthetics, too, are a very potent emotional and psychologic factor in the success of dentures, and that the patients who are happy with the cosmetic results will, many times, endure discomfort and impairment of function. Because it does not relate directly to comfort and chewing efficiency, esthetic consideration will be deferred at this time. We do not mean to minimize the importance of esthetics but prefer to concentrate more specifically on comfort and chewing efficiency in this presentation.

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Comfort and chewing efficiency should receive prime consideration in the restoration of the edentulous mouth because they are two of the most important objectives in denture satisfaction. These often become a definite challenge to the prosthodontist because of the varying factors which influence a successful result. A very thorough examination, history, and study is necessary for a favorable prognosis.

A satisfactory result indicates that the operator has mechanically restored the masticatory organ and has properly made use of the available base areas, that he has employed good quality materials, used the best methods for processing and the proper registrations of the excursions of the mandible, made adequate correction of the occlusal surfaces, used the best judgment as to the proper size and shape of the teeth, and in general conformed to the fundamental principles in the construction of complete dentures.

We must strive for the finest possible chewing efficiency and comfort in complete dentures to facilitate the proper digestion and assimilation of a great variety of foods in order to properly supply the body with the nutrients needed to maintain or restore the health of the patient. It is important that we be aware of the effect which the success of our efforts has on the physiology, the vital structures, and the health and happiness of the patient in restoring an important organ for an important physiologic function.

Studies have been made by many investigators trying to establish the fact that the efficiency of digestion and assimilation is directly related to the efficiency of the masticatory organ. A review of the scientific investigations by men in Germany, Russia, Japan, Sweden, England, and the United States can be found in a very comprehensive paper written by Morris J. Thompson (*Dental Cosmos*, February, 1937). Dr. Thompson also gives the results of his investigations of masticatory efficiency as related to cusp form and illustrates and describes the armamentarium needed to make the tests.

This procedure has been very valuable in comparing chewing efficiency in more recent studies and tests. The tests made with Dr. Thompson's equipment are evaluated on a relative basis and the results or findings are taken on an average of five tests. The information derived is most valuable as a guide in the selection of the form and type of posterior teeth that facilitate chewing efficiency.

The equipment consists principally of a scale for weighing, miniature miter box for cutting food of uniform size, and a set of screen gauges to measure the fineness of masticated food. The technique involves a definite number of cubes of food, of uniform size, to be chewed a specified number of chewing strokes, then deposited between screens of predetermined gauge, and washed a definite number of times. The efficiency is computed by weighing the particles collected on each screen (Fig. 1).

The writer's desire to do some investigating was prompted by the recent advent of acrylic resin teeth and their unknown relation to porcelain teeth as far as chewing efficiency is concerned, and the relative importance of the various cusps of anatomically articulated porcelain teeth. No concrete information was then available to satisfy the curiosity of the writer.

Because of varying opinions between leading prosthetic men on the value of various types of cusps in posterior teeth and for our own information, a series of tests were made to first determine the importance of lower lingual cusps of porcelain teeth in dentures. Some men believe that the lower lingual cusps act more as a food table than a shearing mechanism in the chewing of food, and in nature we usually find many of these cusps out of occlusion and balance, and with plenty of so-called escapeways. Two complete denture cases were constructed using porcelain posterior teeth to make experimental studies and evaluations.

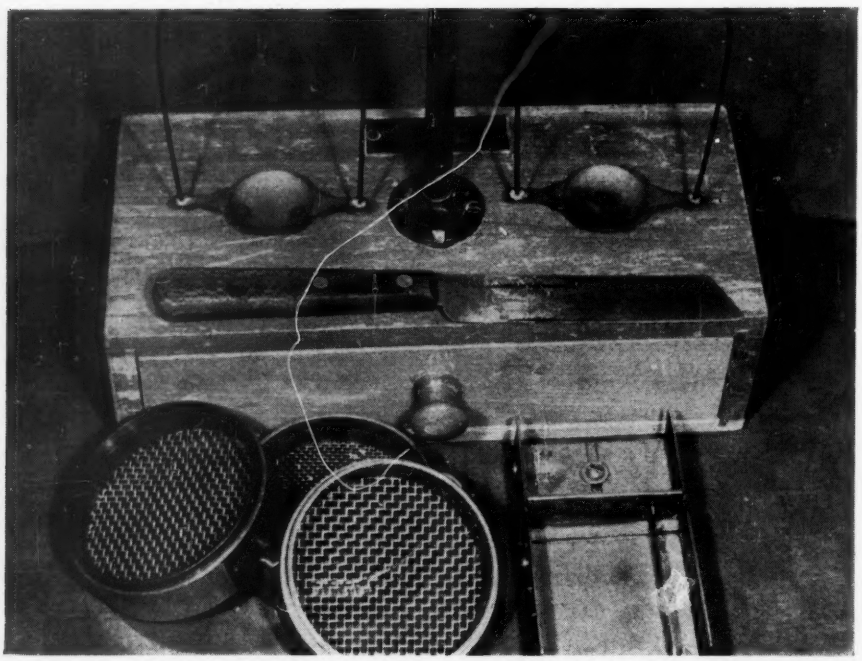

Fig. 1.

We coordinated the teeth in all excursions so that all of the buccal cusps were in articulation and function in all positions, that is, protrusive, right lateral, and left lateral. All lingual cusps were also in articulation and function in right lateral, left lateral, and protrusive. The lower left lingual cusps were then reduced by grinding to become minus cusps (No. 1 dentures). As far as chewing is concerned the loss in efficiency is 32 per cent. In a duplicate set of dentures (No. 2 dentures), the lower right lingual cusps were reduced so that they appeared normal, but in the various excursions were approximately 1 mm. short, or out of occlusion. The tests showed a loss of efficiency of 16 per cent.

Our evaluation, as a result of many tests taken, is that the lower lingual cusp is a very important part of the chewing mechanism.

Another series of tests was made before and after the reduction by the grinding on No. 2 dentures of the upper buccal cusps to a slight minus cusp, and the resulting loss in efficiency was 15 per cent. Tests made on dentures with the

best possible coordination of cusps gave very consistent results; in all of the others there was a much wider variation from which to take an average.

With the growing popularity in the use of acrylic teeth for posteriors, our curiosity led us to investigate their efficiency in chewing. Two sets of dentures were made in duplicate (meaning the same impression, casts, registrations, and articulator as for building one case), the only difference being the use of acrylic teeth in one case and the use of porcelain teeth in the other case, and even the setup of teeth was interchangeable. The best cuspal coordination was incorporated in both dentures in order to make a fair evaluation. A series of many tests over a period of time revealed a loss in chewing efficiency of 33 per cent, using acrylic teeth. On another patient for whom experimental dentures have been built over a period of nine years, our tests showed a loss of 26 per cent in efficiency when acrylic teeth replaced porcelain teeth.

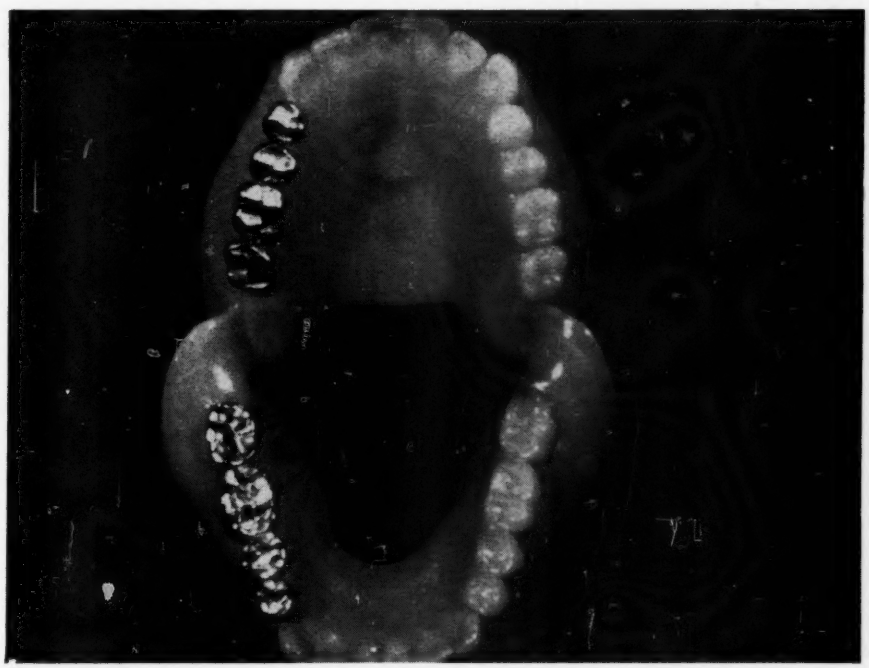

Fig. 2.

It was interesting to find that in both cases the patients preferred and enjoyed the dentures of all acrylic teeth. This preference was based principally on the fact that the shock of contact impact was almost eliminated. The patients were unaware of the materially reduced efficiency in chewing with acrylic teeth to those of porcelain posteriors.

Then, on one side of one of the cases, the occlusal surfaces of the acrylic teeth were reconstructed in gold and comparisons were made in patient reaction and chewing efficiency tests. It was gratifying to find that the contact-impact shock of the gold occlusal restorations on acrylic teeth approached the desirable cushion effect

which acrylic teeth give and with a comparable chewing efficiency attained in the use of porcelain teeth in the same patient with all conditions equalized to the best of our ability.) Because acrylic teeth with cast gold occlusal surfaces do give chewing efficiency comparable to that of porcelain teeth without the shock experienced in the occlusion of porcelain, this method becomes desirable for those people to whom the use of porcelain teeth has a disturbing emotional effect and a feeling of self-consciousness from the noise and shock of occlusal impact. The use of gold occlusal surfaces on acrylic posterior teeth is of practical value also in preserving the chewing efficiency established, a factor which is soon destroyed by wear in some cases where all acrylic teeth are used (Fig. 2).

Fig. 3.

The technique for creating gold occlusal surfaces is relatively simple and has some particular features of its own expressed briefly by comparing it with the advantages of reconstruction or rehabilitation of natural teeth. Cuspal coordination, distribution of cusps, and the size and shape of the posterior teeth are under better control of the operator through wax manipulation and carving in creating desirable restorations. The wax patterns are made and coordinated individually and, after casting the patterns into gold and replacing them one by one for occlusal refinement, a high degree of perfection is possible in coordinating the cusps for function in articulation. This procedure is also desirable for use in removable partial denture construction, and especially indicated where removable appliances are in occlusion with fixed bridge work and other gold restorations in natural teeth. The reactions of those patients for whom we have used this procedure is encouraging (Figs. 3-6).

For the past ten or twelve years we have incorporated in our denture technique the use of a metal lining or base in contact with the tissues, especially in the difficult cases. (It appears from observation that tissues are more compatible to these metal bases than to other denture materials.) The metal bases can be made very accurately and they remain stable, something to be desired in denture base materials. Even though we have often used metal bases on uppers, the greatest need has been in lower dentures. Because of the stability of form and the accuracy of fit, it contributes to comfort in complete denture prosthesis. The technique for making the metal base is quite simple. The area to be included is outlined on the cast. The cast is duplicated in investment and a single layer of 28 gauge wax is adapted to the area desired. A single 12 gauge wax rib is attached edgewise over

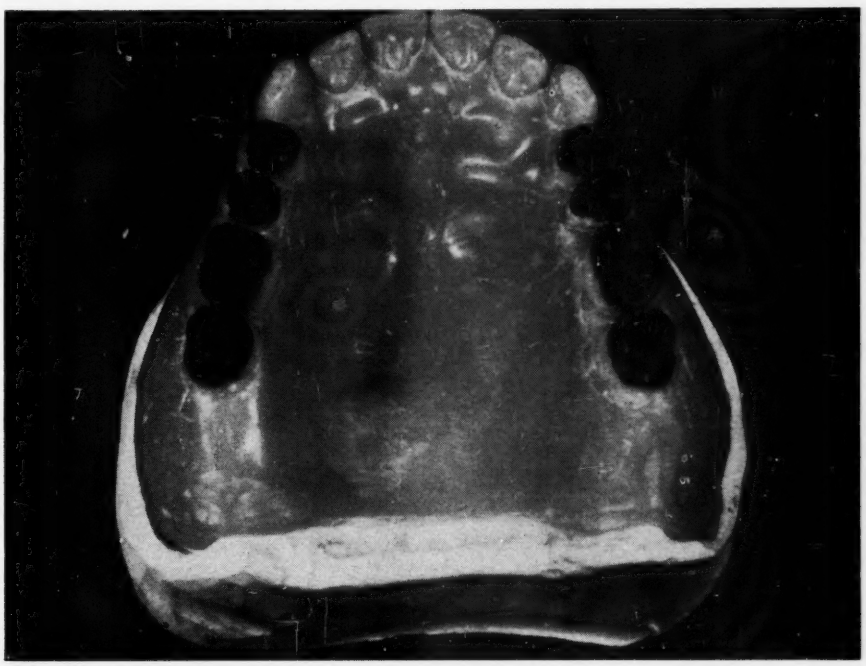

Fig. 4.

the crest of the ridge and a continuous loop of 20 gauge wax for acrylic retention is added. (The gold used in this large case is 10.5 penny-weight.) To preserve adaptation, the tissue side must be left unfinished. The use of the metal base should be routine in all dentures where a bulk of denture material is necessary (Figs. 7 and 8).

Another factor worthy of consideration in complete denture construction is the corrective or adjustment refitting of the lower denture. This is accomplished by the use of impression wax for a functional refit of the lower denture. The wax has many features which merit its use because it acts as an adjustment to the influences over which we have relatively little control while building the dentures.

The wax reline impression is ordinarily used several days or a week after completion and wearing of the dentures. Then, after the wax is placed in the

Fig. 5.

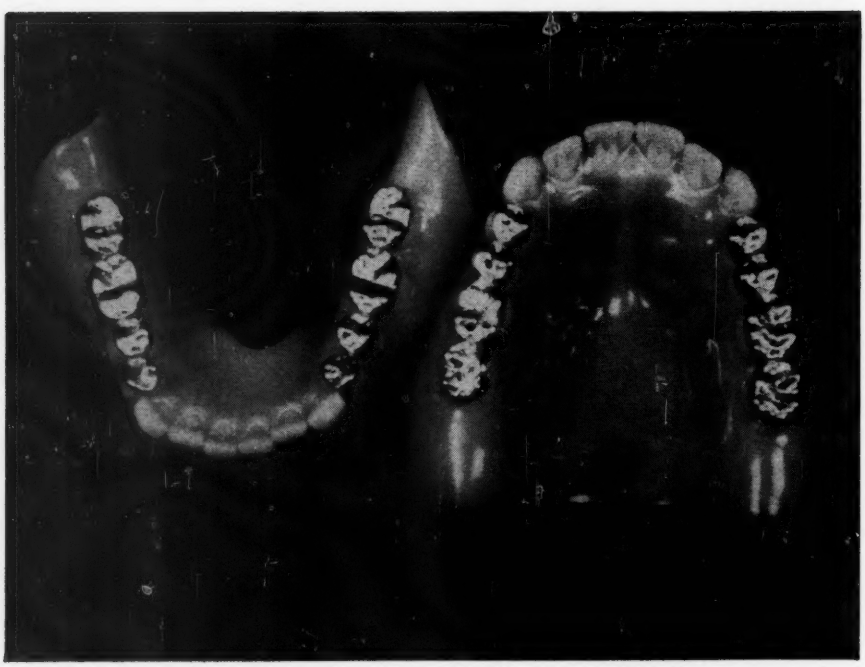

Fig. 6.

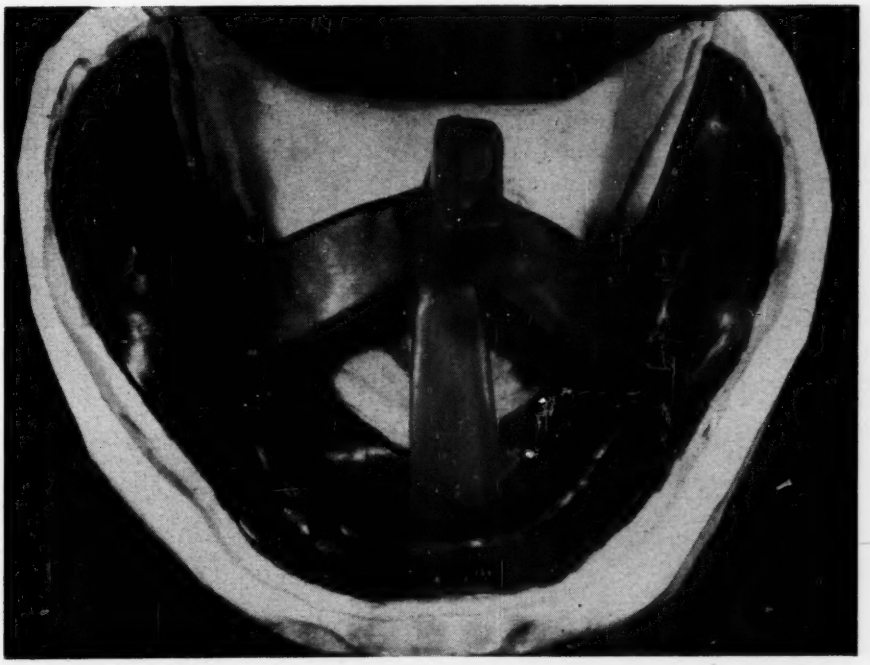

Fig. 7.

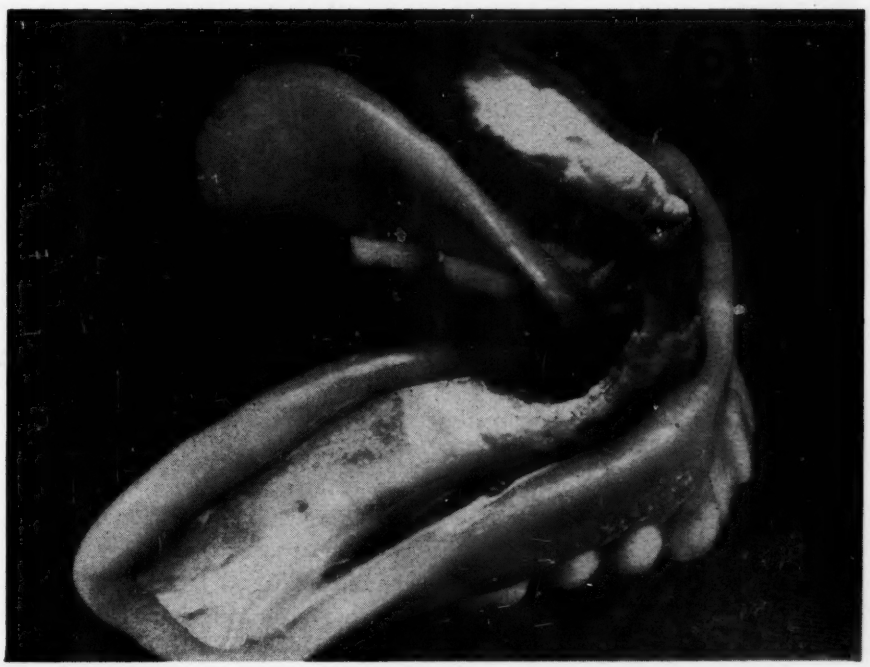

Fig. 8.

lower denture, the patient wears it for several hours. This serves to give us refinements in adaptation and readjustment to many factors of prosthetic concern. Even though it usually is used only in the lower, it automatically compensates for uneven settling of the upper also. It will flow at mouth temperature and has some resistance. This method is of the most value in denture cases with functional coordination of anatomically articulated teeth (Fig. 9).

Gothic arch registrations of mandibular movements are common procedure in denture construction. Even though the apex of the Gothic arch is accepted as centric relation and provisions made in articulation for function as prescribed by the Gothic arch, it is possible that the functional centric may not be in the exact apex. This reline procedure serves to accommodate this adjustment by properly positioning the functional interarch relationship.

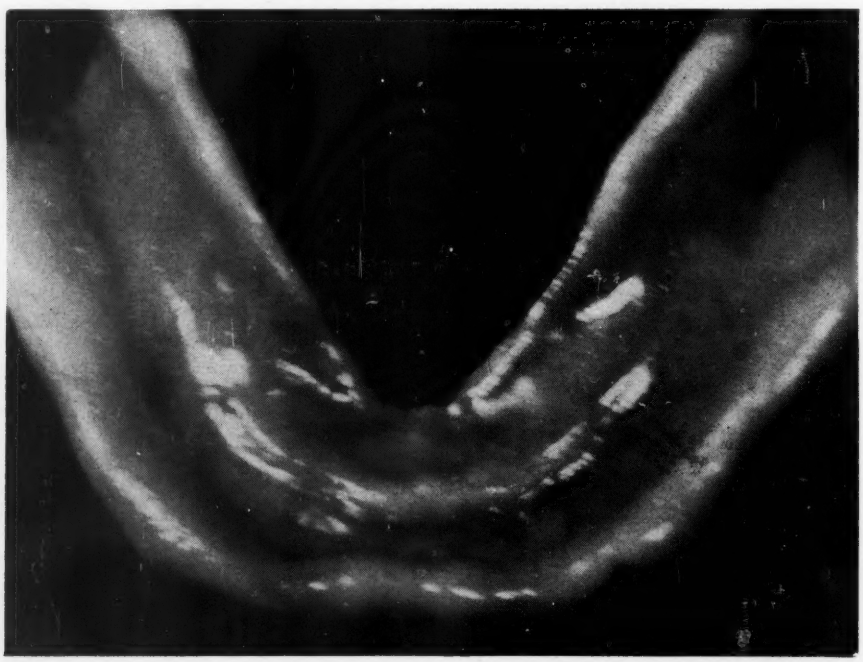

Fig. 9.

The wax reline readjusts and compensates for the force, pressure, and unfavorable torque factors which sometimes are unavoidable in the registration of mandibular movements.

The weight of registering instruments may compress the condylar articulation or base areas unfavorably and the use of the wax impression lining serves as a compensating medium for the adjustment to those influences. The writer is conscious of the unreliability of wax relationships used between natural teeth and the inconsistency of the patient in applying pressure during registrations.

In this procedure the finished dentures have their teeth properly positioned as to ridge relation and other requirements of the case, and the forces applied by

the teeth in function to the base areas beneath them is most desirable because that is the way the patient is going to use them. There is then the equal distribution of pressure applied in function, a very necessary factor easily accomplished by this method.

Another very important feature in the use of this wax lining is the impression refinement derived from the physiologic function of the peripheral tissues serving to adapt the peripheral border and add materially to the stability of the denture. After the patient has worn the wax readjustment lining for several hours, it is chilled with cold water and then prepared in the usual way for a rebase of the lower denture. This, then, becomes the opportune time to introduce the use of the metal base into our denture procedure. The rebase technique can be followed through, including the separating of the flasks and the elimination of the wax. Space provision is made to accept the metal base, and the reline procedure with the metal base introduced is completed.

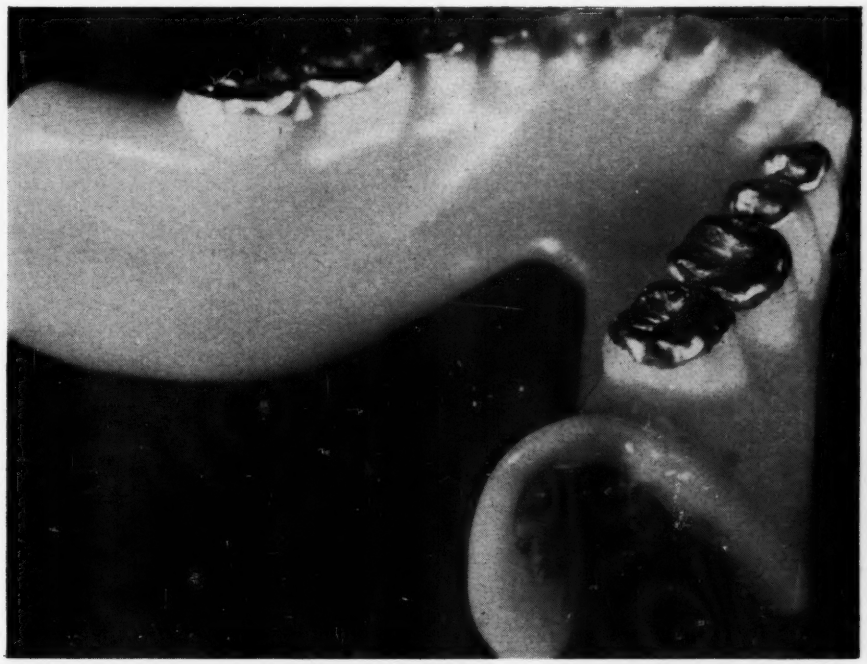

Fig. 10.

To clarify the procedure, several points should be repeated. The dentures, in this presentation with the gold occlusals, are finished first without the metal base. After wearing the dentures a few days or a week, the wax readjustment routine is introduced on the lower and worn for several hours. The usual rebase technique for the lower is used except that the metal base is made from and introduced on the model made from the rebase impression. The space provided for between the lower denture and the metal base on the model is filled with acrylic resin by the injection method, finally completing the case.

We have incorporated the cushion effect of the acrylic posterior teeth, the chewing efficiency of the gold occlusal surfaces, the finer adaption provided by the metal base, and the many adjustment features provided by the wax relining material of the physiologic, functional, and other biologic factors peculiar to any individual edentulous mouth. In short, this procedure includes the use of acrylic posterior teeth with gold occlusals and a metal base introduced with the reline or rebase of the lower denture, together with the reasons therefore (Fig. 10).

We have not only given consideration to important factors which influence comfort and chewing efficiency in complete denture construction, but also illustrated the practical application of the variations to any technique to provide for those factors and considerations. Our conclusions are the result of observations, patient reaction, and tests. The results certainly justify the effort.

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PSYCHOLOGIC FACTORS INVOLVED IN PRESENTING DENTURE SERVICE

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WHEN prosthodontia is considered from a realistic standpoint it becomes increasingly apparent that organized dentistry largely has overlooked the most serious problem confronting the majority of dentists. Contrary to general belief this problem does not revolve around difficulties encountered in the development of better techniques; instead, it has to do with finding ways and means of making the highest type denture service understandable and acceptable to more patients.

Since the depression of the early thirties, in an endeavor to learn more about actual practice problems, this author has interviewed literally hundreds of dentists from all sections of the country. From those frank, down-to-earth discussions, the following facts are evident:

1. That the vast majority of dentists are fundamentally honest and motivated by a service concept consistent with a high ethical standard.

2. That virtually all dentists manifest an eagerness to adopt any improvement that would increase their technical efficiency.

3. That, despite this desire for improvement, dentists in distressingly large numbers have found it economically impossible to employ some of the more advanced techniques, confessing instead to the use of short-cut methods. In other words, too many dentists acknowledge their inability to convince patients of the additional value to be found in painstakingly and scientifically constructed dentures.

Thus, in spite of a fine educational background and an earnest desire to serve the public in the best possible manner, these men found themselves blocked at the outset by patients who seemed unwilling to make the necessary monetary investment that would permit the use of more comprehensive, time-consuming methods. This resulted quite naturally in a decreased interest in postgraduate work because, as one dentist expressed it, "I can't find a sufficient market for the knowledge I already possess." This situation brings to mind the story of the farmer who, when asked to join a group for the purpose of studying better farming methods, replied, "Nope, don't believe I will. T'won't do no good cause right now I ain't farming half as good as I know how."

Read before the joint sessions of the Section on Full Denture Prosthesis and the Section on Practice Management at the Nineteenth Annual Session of the American Dental Association, San Francisco, Calif., Oct. 20, 1949.

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Unfortunately, this statement is too often applicable to dentists. A critical examination of the material sent to any large dental laboratory will force any honest investigator to admit that dentistry is not doing half as well as it could despite its emphasis on technical training.

This does not imply that too much emphasis has been placed on mechanical dentistry. It would be more constructive to say that one phase of practice has been underemphasized. While remarkable scientific advancements have been made since dentistry emerged as an independent profession, the economic factors governing practice have been almost completely and totally ignored. Academic and postgraduate work should be modernized so as to bring about a balance between the ability to produce and the ability to distribute good dentistry.

Hence, two types of ability are required for success in this particular field; the ability to produce good dentures and the ability to create an appreciation for that service. It is quite significant that the development of these abilities demands different approaches. Many are fortunate enough to possess ability along both lines, but long research has shown that one does not necessarily develop the other in that they represent two entirely different types of intelligence.

Snow[1] divides intelligence into four classifications:

1. *Artistic intelligence* is the type possessed by great writers, poets, painters, sculptors, and musicians.

2. *Verbal intelligence* is used when dealing mainly with abstractions. It is the intelligence used in ordinary thinking. It is the kind chiefly measured in I.Q. tests.

3. *Mechanical intelligence* is the intelligence of the mechanic, the engineer, the technician who deals not in abstractions but in concrete things. The watchmaker repairing a watch, the surgeon or dentist performing an operation is using this type of intelligence.

4. *Social intelligence* is the type used when working with people; it is the intelligence of the leaders of men, of the statesman, the popular lecturer, the influential religious leader, and the salesman. It is the kind of intelligence that has been sadly neglected in modern education.

It would be ideal to possess all four types, yet few can hope to attain this perfect balance although everyone possesses each of these faculties in some degree. Their relative importance so far as dentistry is concerned may be debatable, but one thing is certain—all those who hope to be successful in dealing with people must have social intelligence which is the ability to understand people, to see their point of view, and to feel emotionally with them.

Dentistry has been slow to recognize this fact, and for many years our educational system has been based on the assumption that artistic and verbal intelligence together with a generous portion of mechanical ability will produce the ideal dentist. Because of this incomplete educational background, the importance of social intelligence has received scant attention. Dentists have been concerned with developing skill in the use of instruments and materials, mainly, not realizing that skill alone may benefit no one.

It is not surprising, therefore, that most dentists experience considerable difficulty in solving the acceptance problem encountered in the practice of prosthodontia. The construction of modern dentures requires the ability of a well-trained dentist. Likewise, the acceptance of that service by the patient requires the thoughtful use of applied psychology.

Few dentists have the time or the desire to become authorities on the subject of psychology. It is a life study in itself. There are, however, certain principles based on an understanding of human behavior that, if properly applied, will enable one to be far more effective in dealing with patients. This study need not delve too deeply into the science of the human mind and its activity, but it is advantageous to have an understanding of basic psychologic principles.

White[2] states: "In most instances, our failure to get others to comply with our wishes is due to a lack of understanding of man's basic wants; the driving and persistent nature of these wants and to a lack of knowledge as to how one should proceed in harnessing these wants."

Fortunately, it is not necessary to study all of these basic wants to have a working knowledge of human behavior. Only one need concern the dentist to any extent, but this one is of special importance because of the tremendous influence it exerts on the actions of every individual. It is called the "Want for a Feeling of Personal Worth."

Someone has said, "Life is many things, it is food getting, shelter getting, hoping, arguing, aspiring, sorrowing; and in the center of it all, is the process of getting ourselves believed in and accepted." This desire for self-adequacy, the urge to be somebody, to attain prominence, to rise above mediocrity, is one of life's most powerful drives.

Children "show off" before guests, the young boy smokes his father's pipe, the teen-age youth asserts himself by disdaining paternal advice, the college sophomore exudes wordly wisdom, and even maturity does not lessen the intensity of this never-ending search for adequacy. People will go to almost any length to "save face" or avoid "losing face." When it is realized what a tremendous influence this desire for a feeling of personal worth exerts on the behavior of man, it becomes quite evident that a recognition of this fundamental factor constitutes a major control in influencing people.

Thus, to be successful in dealing with patients, matters that deal with the importance of the patient should have the conversational spotlight. In so doing, the dentist yields the center of the stage to the man in the chair and, strangely enough, becomes the possessor of a charming personality.

Personality might well be called the display window of an individual. It is that part of one's true self that others may see. For this reason, the personality of every person should be unobtrusively displayed in such a manner that it will be as attractive as possible. This "display window" can be pleasing and inviting, or it may be so unattractive that few care to investigate further what might be within.

There are many who always have considered personality an inherited characteristic, like the color of the eyes or the shape of the head. Fortunately, that

is not true. Personality should be defined as "the effect we have on other people" —which classes it to a large extent as an acquired characteristic.

Personalties are just as susceptible to development as a flabby muscle. All one need do is to cultivate traits that please people and avoid those that offend. While this definition offers considerable encouragement, it also adds a disquieting note, for no longer may bad manners be excused with a shrug of the shoulders and a "sorry-but-that's-just-the-way-I-am" attitude. Social habits can be changed by anyone who seriously desires to improve.

Seven basic personality traits will be considered in the light of their influence on success in dentistry. Maximum benefits will be obtained only by those who make an honest attempt to search for personal shortcomings, because of general failing to underestimate grossly personal weakness.

BE AGREEABLE

A group of postgraduate students was asked by Crane[3] to select the dentist they considered best of those they had visited and write down the reasons for their choice. First on the list, when their answers had been tabulated was, "He was cheerful, friendly, and congenial."

This may be surprising to professional men, but it long has been known in the business world that 47 per cent of the people who discontinue buying at one particular store do so because of alleged discourtesy on the part of some employee.

Courtesy, politeness, and accommodation cost not one cent, yet they may be sold. Some of the most successful dentists keep a card index system under which is listed personal information about each patient and his family. By the dentist's being conversant with affairs that are of personal interest, each patient is made to feel that he occupies a position of special importance in the practice. The dentist who can make patients "feel at home" in his office need have no concern over what the future may hold; his practice will be little affected by floods, drought, crop failure, or postwar depression. Without attempting to minimize the importance of good work, it must be remembered that patients are won and held by carefully organized courtesies.

BE A GOOD LISTENER

Few forms of entertainment can surpass conversation as one of life's most interesting and enjoyable pastimes, especially if the subject under discussion happens to be ourselves. Because of its universal appeal, and because it affords everyone so much pleasure, people often are guilty of overindulgence. Those who monopolize the conversation are having a wonderful time; but what about the other fellow who also would like to express an opinion now and then? There is one definition of a bore that should be solemnly repeated by everyone at the beginning of each day. It goes like this: "A bore is the fellow who keeps talking about himself when I want to talk about myself."

All highly successful men recognize this trait in others and they, being more eager for control than self-aggrandizement, have cultivated the habit of listening,

not merely remaining silent while another speaks, but giving others their undivided attention. Too many people are so concerned about what they are going to say as soon as an opening presents itself that they do not really listen. Listening is an art. Some individuals, without uttering a word, can be more flattering than most people. Whosoever talks to such a person, be he day laborer or financier, faces a person who hearkens gravely, attentively, eye-to-eye, until the speaker is quite finished. Nothing is more flattering than to receive undivided attention. It is not only an easy way to charm people but an almost certain method of creating a favorable impression.

Clay W. Hamlin, a very successful insurance salesman whose writings are almost universally quoted in insurance sales manuals, says "about 90 per cent of each of my interviews is devoted to listening. The quicker we give a man an opportunity to speak, the quicker we shall get the response we want. Let people talk; they are really thinking out loud."

If patients are encouraged to "think out loud" it gives the dentist an opportunity to size up each individual, to learn something of his likes, dislikes, prejudices, and to plan a presentation accordingly. Before services can be rendered, this acceptance problem must be solved. If the dentist is to enjoy maximum success he must, of course, be a good conversationalist and an enthusiastic educator, but, first of all, he should be a good listener.

AVOID ARGUMENTS

It must be remembered that force never won a permanent victory on the battlefield, and verbal force, which is just another way of describing arguing, never has been and never will be a successful means of settling differences of opinion. This does not mean to avoid a necessary battle. There are times when one must fight for principles. No man endowed with the customary attributes of vanity or pugnacity can be browbeaten or overawed into changing his opinion Attempts to do so only make him stubborn. Even when by sheer weight of facts an individual is forced flatly to admit he is wrong, it is unwise to cram the unpalatable truth down his throat. To do so would mean the almost certain loss of his good will.

Several years ago this point came up with one denture case. A wealthy influential club woman had some very positive and utterly ridiculous ideas as to how her denture should be constructed. Her dentist, being young and inexperienced, did not hesitate to express his disagreement with every one of her suggestions. The discussion soon degenerated into an argument from which the dentist finally emerged the admitted winner. That evening he told, with considerable pride, how he had told the old dowager "where to get off" and how finally, he had "put her in her place"—her and her silly ideas. And it was true, he had put Mrs. C. in her place; he also put her squarely in another dental chair. With all her faults, Mrs. C. had many good qualities, one of which was an ability to write checks of considerable size that always arrived not later than the tenth of the month. This tactless young man had not yet learned that one can

convince few men and certainly no woman by arguing. Much to his sorrow he discovered that arguing is a very expensive pastime that can be enjoyed only by debators and those who are independently wealthy.

Every successful businessman knows that it is possible to win an argument and lose a sale. They also know that, in the quest for orders, an ounce of suggestion is worth a whole ton of argument. Crane[4] says, "Guide me deftly to the decision you want me to make—don't crowd, don't shove, just feed me ideas as fast as I can absorb them. If you can influence me to persuade myself, I'll sign."

Therefore, when tempted abruptly to contradict or take issue, this question should be asked, "What do I really want? Do I want to win an argument and make an enemy, or do I wish to gain my point?" It should be remembered that the winning of an argument for argument's sake may defeat the purpose.

CRITICIZE TACTFULLY

According to students of human behavior, every course of action followed throughout life has been selected because it gives more pleasure than pain. This means that all acts have been fully justified in the minds of every individual even before they are carried out. That statement may sound rather improbable but it is none the less true.

At the country club, one seldom hears such a remark as "I played miserably today; I'm a terrible golfer." Instead, you might hear, "My score wasn't very good, but I never can play in the wind," or "Started out fine, then my back started hurting again and I had to ease up."

The student blames his low grades not on a lack of study but on the fact that "The teacher had it in for him." Those who have failed miserably in business find consolation in the belief that their failure was due entirely to "bad breaks."

So it goes, not only in golf but in everything else. There are excuses, alibis, logical reasons for failure—anything but self-criticism.

In general, it can be said that criticism is futile because it aims a death blow at one's self-respect by undermining the feeling of personal worth. Criticism places people on the defense; it makes them appear foolish and silly. It usually opens up deep wounds that never heal, but fester down through the years. Yet it is possible to criticize and accomplish the proper results without offending. It merely requires a little tact.

A young man had spent hours in the preparation of a paper which was to be presented at a large meeting. He asked a friend who was quite experienced as a public speaker to make suggestions and offer criticisms. When his friend finished reading the manuscript, the young man was quite flattered to hear, "That's fine—splendid — you have some of the most unique ideas ever heard expressed." The author was delighted and pressed his friend for suggestions as to how the paper might be improved, even in the slightest manner. "Don't suppose I can help much, but do you think the ending would be more effective if it went something like this?"

was the guarded comment. Why, of course, it was as plain as could be. Then perhaps the introduction could be altered to advantage, was the next suggestion. Suddenly the young man was seized with a happy thought—with the introduction and conclusion altered, it would be only natural to make some changes in the body of the paper, so why not re-write the whole thing? It was perfectly all right though, because his own unique ideas remained undisturbed.

What an excellent policy to follow: compliment first, then tactfully offer constructive criticism.

DON'T BE EGOTISTIC

With a moment's reflection, it will not be difficult for one to recall the names of many acquaintances who have, as their most conspicuous fault, an exaggerated opinion of themselves. These individuals simply cannot wait for others to discover their good qualities; they extol their own virtues at every opportunity and, in so doing, arouse a feeling of antagonism among those with whom they come in contact.

While it is only human nature thoroughly to enjoy seeing such braggarts stripped of their glory, a more tolerant attitude toward these individuals will be taken when it is realized that a superiority complex and an inferiority complex are one and the same thing. Those who enlarge, exaggerate, and monopolize all conversation merely are using such tactics to bolster up a feeling of inadequacy.

Those who are content in their own minds find it unnecessary to attract attention by exaggerations or egotistic statements. They have found mental peace; therefore, such tactics serve no purpose. These people usually are kindly, courteous, thoughtful, and modest. They never demand attention or credit for what they have done. Instead, they give credit freely and find it returning a thousand fold.

To hand the patient a mirror and say, "Here—take a look at the wonderful set of dentures you are to wear—aren't they beautiful?" may elicit a grudging compliment, but more often than not it will merely serve to cheat the dentist out of well-deserved praise.

One prosthodontist quite by accident made a significant discovery regarding the value of modesty when he dismissed a patient in the following manner. He had just delivered a set of dentures to a very charming old lady who had been an exceptionally fine patient. Forgetting all about himself, this dentist attempted merely to express his gratitude by saying, "Mrs. Jones, I can't tell you how much we have enjoyed making your dentures. You have given us excellent cooperation, your attitude has been ideal, and I can truthfully say you are one of the finest patients for whom we have ever worked. It is true your case did present certain difficulties but with your help we were fortunate in being able to obtain a result that meets with our entire approval. I feel confident that you are going to enjoy wearing these dentures. My assistants and I have thoroughly enjoyed your visits to our office and we hope that this marks the beginning of a long personal friendship."

A flush of genuine pleasure crossed her smiling face. "Thank you very much, Doctor," she said, "that's one of the nicest things anyone ever said to me." And then she unknowingly taught her dentist a valuable lesson, one he has tried hard

to remember down through the years, when she added, "And, Doctor, I want you to know I think you're wonderful too!"

REMEMBER NAMES AND FACES

One evening, a young mother said to her husband: "I don't think Dr. X is really interested in children. Perhaps we should change doctors. Even though he has taken care of Junior since he was born, today when we entered his office he glanced up and said, 'How's the little girl?' That was bad enough but a moment later he said to Junior, 'Come over here, sonny; let's see now—what's your name?' "

Her husband laughed and tried to point out that Dr. X was a good pediatrician whose ability certainly should not be judged by how well he could remember names. People should be above that but, later, when telling the story to one of his friends this young father admitted shyly that it did rather surprise him to think that the doctor could forget the name of the cutest, smartest little boy in the whole city.

Why not give people nourishment for their self-esteem by making it a point to remember their names? Anyone, who wishes, can improve his memory simply by listening attentively and concentrating on the name at the time of the introduction. Remembrance can also be aided by association with a physical characteristic. Perhaps a safer method is to place names of patients and their children on a card, together with any other information deemed worth while. It will then be possible to refresh one's memory before patients arrive and become known as a dentist with a very retentive mind.

BE INTERESTED IN OTHERS

Because of the nature of the work, dentistry tends to develop introverts. That is to say, dentists in general become more interested in things than in people. For that reason all professional men should put forth every effort to acquire more characteristics of the extrovert by developing an other-than-self-awareness. Because of the inherent tendency to be primarily interested in oneself, it is not an easy task to put the affairs of so engaging a person as oneself in the background. It remains, however, as excellent training for one who would develop an interest in others.

It has been suggested by Crane that a deliberate search be made for traits in others that honestly can be complimented. This does not mean flattery, which carries no weight because of its insincerity; instead, it means honest appreciation for the many fine qualities that may be found so easily in others. Friendly observation will disclose remarkable traits of character. People are *so* miserly with praise and so quick with criticism. Why not reverse the procedure and adopt a policy of giving flowers to the living while they can be enjoyed? This simple, easy beginning not only brings more joy and happiness to others but it has a mysterious tendency to remove obstacles which heretofore have blocked the path to success.

There is something far-reaching and deep-seated in actually learning to forget self. It is far more important than it might appear on the surface, because it is indicative of a change that has taken place inside. Those who acquire the habit of

being interested in others find that, without making any conscious effort, without realizing exactly why, they hold in their hands the key, the open sesame to the hearts and minds of people. These individuals have plenty of friends, they always have customers or clients, and, if they happen to be dentists, their offices are filled with patients. It is important to realize that a real personality is not a veneer, it is not a pose or a certain set of words or actions as many seem to think. Those who would possess the right kind of a personality must by their actions demonstrate an honest, sincere, unselfish interest in people.

These seven personality traits are not new. They have been widely discussed in many books by eminent authorities in the field of psychology. They again have been emphasized because, in their simplicity, they are apt to be overlooked. Many wonder as they go through life why they fail to achieve success. They look for some big, glaring fault on which everything can be blamed. They do not realize that success, like a technique, is made up of any number of things, one of which is a pleasing personality.

Fortunately, a pleasing personality can be developed by anyone who applies himself. It merely takes practice and a lot of hard work. The chief difficulty seems to revolve around the fact that people are blind to their own faults, glaring though they may be to others. Social intelligence can be developed by anyone who has the fortitude to look honestly and soberly in the mirror. It takes a lot of courage to indulge in honest self-analysis, but great are the rewards for the man who does so with a firm resolve to change that which should be altered.

The most pleasing personality in the world, valuable as it may be in attracting and holding patients, will not in itself solve the acceptance problem. Something else is needed and that something, for lack of a more acceptable term, must be called ethical salesmanship. For years dentistry has dodged around the word "salesmanship," frantically trying to avoid its use yet completely overlooking its ethical concept. Various ambiguous terms have been used such as "patient education but no satisfactory substitute has as yet been found. Ethical salesmanship is not education alone—it is "motivated" education.

The dentist has no desire to become a salesman, as such, but certainly he should not ignore the lessons to be learned from this fine art of social service. This type of salesmanship has no relationship to the unethical application of the sales principles that brought selling into disrepute during the high-pressure days.

As pointed out in a previous article,[6] ethical salesmanship is the art of making people want what is good for them—no trickery, just an honest attempt to help people procure a greater measure of contentment by guiding their thinking in an educational way. That is the only type of selling that should be used by a professional man. There can be nothing unethical in the accomplishment of this end if the dentist is motivated by a sincere desire to help his patients.

However, there are certain requirements that must be met by those who would make an ethical application of the principles of motivation to the practice of dentistry.

EXCHANGE PLACES WITH THE PATIENT

The first requirement is to make an honest effort mentally to exchange places with the patient and try to understand his point of view. Said Henry Ford: "I am convinced by my own experience, and by that of others, that if there is one secret of success, it lies in the ability to get the other person's point of view and see things from his angle as well as your own."

No doubt every dentist at various times has wondered just how it would feel to lose all his teeth and be forced to wear dentures. If all dentists by some quirk of fate could serve an "edentulous apprenticeship," there would be a remarkable change in the attitude toward denture patients. It then would be easier to understand exactly how people feel when that long-dreaded visit to the dentist no longer can be avoided. Seeing such things every day, the operator is likely to become callous and view each new case strictly as just one more set of dentures to be made. From the patient's viewpoint, it represents one of life's tragedies. One businessman said: "I can't bear to even think about losing my teeth; it would be like dying a little." Such is the attitude of most patients who view their loss of teeth as that critical period when a final transformation must be made from youth to old age.

These emotional elements make prosthodontia fascinating to those who enjoy the human side of dental practice. It is not merely the clever manipulation of compound, the skillful registering of mandibular movement, or the scientific control of materials. It represents a chance to do something worth while for people at a time when things seem darkest. Patients fear the unknown. They fear the extractions, the waiting period, and, most of all, they are horror-stricken at what they have seen in the mouths of others. What an opportunity for the man who emotionally can exchange places with his patients and deal with their problems as he would have his own dealt with. For all is not lost. Giving up natural teeth is not the end. With infections removed and expression restored by modern, well-constructed dentures, the vigor and appearance of youth will likely be regained. This can be the dawn of a new day.

WANTS VERSUS NEEDS

The type of service that will accomplish the best results having been selected, it now is the duty of the dentist to make the patient want what he needs. But there is a vast difference between a want and a need. A man may need things and never buy them. He may need life insurance, yet put off purchasing protection for his family year after year. A patient may need a new set of dentures, yet solemnly declare that he cannot afford them.

But watch this same man when he really wants something and see how quickly he buys, even though he must go heavily into debt. People are forever making arrangements to purchase things they want, while their needs lie dormant until they are unearthed and brought to light.

This story in a book by Worsham[7] illustrates the point: An oil burner salesman called on a well-to-do gentleman who lived in a large drafty brick house.

After hearing all the virtues of automatically controlled oil heat, the old man remained unmoved, assuring the salesman that he was well pleased with his present heating arrangement.

As they finished talking, the dealer was horror-struck to see a little child with no legs come rolling into the room on a little platform supported by small wheels. The owner of the house explained in a heartbroken way that the child was his grandson—all that remained of his family. An automobile accident had taken the lives of both parents and left the child maimed for life.

A thought flashed through the dealer's mind and he asked, "Are you sure these floors are always warm for this little chap to play on?" For the first time the grandfather's eyes showed a flash of interest and he finally admitted that the fire sometimes did get low and the floors did get cold—the floors to which this helpless little fellow was forever chained by his condition. In twenty minutes the deal was closed and the salesman walked out of the house with an order for the installation of one of his largest units.

Why didn't the old gentleman realize the floors were cold—he should have, he lived there. But the point is he didn't. Nor did he realize that he had use for an oil burner until this salesman guided his thinking and made him want what he needed. It is significant to note that the grandfather didn't buy an oil burner —he bought warm floors.

The really effective salesman is no miracle man, nor is he endowed with mysterious supernatural powers bordering on hypnosis. Instead, upon recognizing a definite need, he plays the role of an explorer continually searching, probing, for that hidden button, which when touched will make the person realize and want what he needs.

INTELLECT VERSUS EMOTION

When one applies this interesting thought to the practice of prosthodontia, the question arises—how shall one proceed in finding these hidden buttons? Is it best to give logical, factual reasons why a man needs good dentures or should one attempt to stir a person by using a much more powerful force—an appeal to his emotions? Certainly it was not pure logic that sold the oil burner.

Brownold[8] states: "While the two are closely related, there never was a man who was not more susceptible to an emotional appeal than an intellectual one. The appeal to the intellect makes us think, while an emotional appeal makes us feel."

Whether one believes it or not, the fact remains that all important actions a man takes during his lifetime—from the cradle to the grave—are all the result of his feelings and his heart, not the result of his reasoning power, nor the activity of his brain.

A tastefully dressed middle-aged woman with a very pronounced closure of her vertical dimension asked if we would care to see one of the finest sets of dentures that had ever been made. According to her, she could do anything with them—eat

corn off the cob, bite through apples, etc. To impress the dentist further, she solemnly declared that not once had she been bothered by so much as a single sore spot.

To criticize the dentures would have been the height of futility so this is what was said: "Mrs. V., I want to compliment both you and the man who made that wonderful set of dentures. They look well and they must function beautifully. May I ask—how long have you worn them? Eight years? Have they ever been refitted? No? How remarkable. Of course there are certain changes that take place in every mouth, a change brought about by the shrinkage of the ridges. This shrinkage permits a settling of the dentures which results in an unflattering alteration of facial expression, with the nose and the chin coming a little too close together. There has been some change in your case, but nowhere near as much as one would expect to find in eight years.

"In your visits to our office with your granddaughter, I always have admired your excellent taste in the selection of clothing. That, plus careful attention to details, always gives you a very youthful appearance, marred only by the condition just mentioned. That being the case, this thought flashed through my mind. Some day you might be interested to hear how we can make you look as youthful from the nose down as you do from the nose up. No hurry, of course, just anytime you happen to get around to it."

Mrs. V. had no use for new dentures; she already was wearing one of the "finest sets of teeth that had ever been made," but the following week she purchased a more youthful appearance.

The needs are there—one sees them everywhere, and if dentists are thoughtful enough and persistent enough in their search, they will uncover the motivating force that will make people want what they need.

MAKE IT PLAIN

All attempts to influence people will meet with failure unless the dentist uses terms the patient can understand. Technical words and phrases are all right for dental meetings but they should be carefully avoided when talking to patients. People hate to admit they do not understand, so rather than ask for an explanation they reason it out their own way and often arrive at wrong conclusions.

One dentist told a patient that his case called for the insertion of two "Akers," meaning, of course, two cast partial dentures. The patient looked rather puzzled. Then after a moment he said, "What do I want with two more achers? I just had all mine removed."

It is far better to use simple words and make certain that people understand. If the dentist's presentation cannot easily be understood by the average eighth-grader, he is talking over the heads of most patients. This always must be remembered. "The human mind refuses to accept that which it does not understand."

Illustrative material, such as pictures, slides, and demonstrating models, all play their part in this educational process, yet the value of well-chosen words and sentences has not been sufficiently emphasized.

Joseph Conrad, the English novelist, was asked how he made his livelihood, and he replied, "I am a dealer in words, and words are, of course, the most powerful drug used by mankind. Give me the right word and the right accent and I will move the world."

Ever since men learned to communicate with one another there has been that continual search for the right word and the right accent. Unusual ability along this line sometimes turns failure into success, it helps build businesses, it makes leaders, it crowns kings, and in many instances it has changed the history of the world.

It is admitted freely that nowhere in the English language can words be found that have much appeal and still apply to dentures. But perhaps dentists would meet with greater success if, instead of emphasizing the kind of teeth, the color of the base material, or the methods used in taking impressions, more time were spent searching for the right word and the right accent. Perhaps in speaking of dentures it would be better to use terms such as "wrinkle removers," "an investment in youthfulness," or "painless face lifting." A re-establishment of normal facial contours could be called a "way to turn the calendar backwards."

A college professor had been told he never could wear dentures because of certain difficulties connected with his case. For years he had attempted to save his teeth but the day finally came when further restorative work was impossible. He was quite worried over the prospect of wearing dentures but his main concern seemed to revolve around what it would cost. In discussing the problem with him it was quite evident that nothing had been said to arouse his interest. Finally an opening was discovered. He said, "When a fellow reaches my age and starts to go downhill, I can see no justification for spending that much on plates."

This poor fellow thought he was a "has been" at 52. He thought his day was done. Here was an opportunity for the dentist to do far more than construct a set of dentures. This man needed to re-establish confidence in himself. From that point on, the presentation took a different turn. It was pointed out that this livelihood depended on his ability to appear at ease before audiences and that his mouth condition undoubtedly had contributed to his feeling of depression. The dentist painted a word picture of a new professor, standing before his classes with renewed confidence, sharing with others the wisdom that comes only with the passage of years. This was far more than a denture problem—this was to be an "investment in personality development."

"An investment in personality development," he repeated, "say, you've got something there. Yes, sir, it would give a fellow more confidence if he had a good set of teeth, and it would be worth it."

The most interesting part of that particular case was not the construction of the dentures themselves, but in slowly and carefully restoring this man's confidence in himself by building up his feeling of personal worth. Accounts in the newspapers of his speaking engagements plus the accouncement that he was to take over as head of his department give proof that for him it has indeed been the beginning of a new day.

It would be very enlightening if every dentist would make a recording of his presentations; then listen to a "play back" after the patients leave. Most everyone would be surprised, if not shocked, to hear what actually was said. It is a guaranteed method of arousing interest in a more careful selection of words and sentences.

GIVE PATIENTS A CHOICE

Most people pride themselves on being careful buyers—that no purchases are made until due consideration has been given all factors involved. For this reason, even after having definitely decided to purchase the best, fewer regrets will disturb their peace of mind if they have at least looked at something less expensive. Therefore, when discussing dentures, patients will find it much easier to arrive at the decision which will be for their own best interest if their case is planned in more than one way.

This suggestion is far more important than it may appear because around this idea revolves an interesting bit of strategy. In giving a choice between two or more plans, a patient's attention can be diverted from the question, "Shall I or shall I not have this work done" by placing emphasis on "which" case will best suit his needs.

The clever wife uses this idea very effectively when she decides it is time to purchase a new hat. Instead of making the fatal mistake of saying, "John, do you mind if I buy a new hat," she brings home two hats and after a meal consisting of all John's favorite dishes, she smiles sweetly and says, "John dear, I need your advice. Your taste in hats always has been excellent. Would you please tell me which of these two hats you think looks better on me?" It matters not how poor John answers the question, for anything he says will cost him exactly one new hat.

This idea, thoroughly understood and thoughtfully applied, will prove to be of great value in helping patients decide. Cases can be planned in two or more ways, but instead of calling them "best," "medium," or "cheapest," the dentist might meet with more success if he called his best plan the "ideal" plan, then offer a "compromise suggestion" and possibly an "alternate plan." Then, after explaining the various methods, he can help the patient come to a decision which will be for his own best interest by asking, "Which case do you feel will best suit your needs?"

CONCLUSION

It is hoped that this paper will help stimulate more interest in the psychologic problems encountered in presenting denture service, a phase too long ignored. For many years, emphasis has been placed entirely on the development of technical proficiency, overlooking the cold fact that, in this streamlined atomic age, it is not enough to have become skilled in one's chosen field. As a result of this attitude, schools graduate men with a fine scientific background, but with little or no training in how to make patients see the value in dentures painstakingly and scientifically constructed.

Surely the time has come to look honestly at the practice of dentistry, and recognize the need for a balance between the ability to produce and the ability to

distribute good dentistry. It is the responsibility of every dentist to conduct a never-ending search for improvements that will benefit his patients, and it is the function of organized dentistry to furnish such information through its meetings and publications. But organized dentistry should function in another capacity. It should serve as a clearing house for reliable, authentic information on how the principles of applied psychology can be used to make the highest type denture service understandable and acceptable to more patients.

If the public is to enjoy the benefits of scientific research, if the dentist is to reap a just reward for honest service, organized dentistry must teach its members how to become as modern in dealing with patients' minds as in the treatment of their mouths.

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THE DENTAL PROBLEMS OF SENESCENCE

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THE overwhelming emphasis on pedodontics has made us partly blind to the urgent dental problems of the aged. In the present population of the United States it is estimated that there are 11,000,000 persons past the age of 65. In twenty-five years it is believed that this population will increase to 20,000,000 persons. This means that if the dentist population in 1975 is 80,000 practicing dentists each dentist will have a potential of 250 persons past 65 years of age in his practice.

It may be well to agree on terms of reference in considering the problems of the aged:

Gerontology involves all the divisions of the biologic, physical, and social sciences.

Geriatrics includes all the aspects of medical care for the aged.

Gerodontics includes all the aspects of dental care.

What do we know of the biology of aging? Unfortunately, we know but little. We do know that the rate of aging varies among age groups and among the various tissues of the body. Aging begins at conception and 99 per cent of the growth potential is expended during intrauterine life. Stieglitz,[1] who has done as much as any clinician to make us aware of the biology of aging, expresses this point of view:

"The trajectory of human life follows a well defined pattern. Grossly divided into three periods, evolution, maturity, and involution, there are several obvious subdivisions of these phases. Intrauterine life is divided into embryonic and fetal stages. Postnatal evolution recognizes the periods of infancy, childhood, puberty, and adolescence. These are none too sharply demarcated; no exact measure is possible by chronologic age alone. The normal rate of development varies within fairly wide limits. From maturity onward, however, the subdivisions are even less distinct. The haziness of this part of the curve of change is due in part to the fact that the effects of aging become less and less obvious and are much more gradual in their evolution and also because of past lack of clinical interest and study of the age factor in health and disease in adults. The manifestations of aging are conspicuous and dramatic in infancy and youth. Aging change, and aging *per se*, proceed at ever diminishing rates, though the deceleration is not constant.

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"The various specialized cells of the complex mammalian organism do not all age at the same rate. Cells which divide frequently, such as those of the basal stratum of the epidermis, are very short lived; their individual span of life is from one mitosis to the next. Others, as for example those of the central nervous system, live as individual cells as long as the organism survives. Between these two extremes are many variations, not only in the specific cell types or tissues, but in functional units, organs, or systems . . . . The elderly are not just 'old people'; they are structurally, functionally, and mentally *different* men and women than they were in the days of their youth and early maturity."

Before any consideration of the specific aspects of gerodontics, we should have an over-all view of the characteristics of the aging tissue. Carlson[2] characterizes progressive age change in these categories:

1. Gradual tissue desiccation.

2. Gradual retardation of cell division, capacity of cell growth, and tissue repair including reduced capacity to produce immune bodies.

3. Gradual retardation in the rate of tissue oxidation (lowering of the basal metabolic rate).

4. Cellular atrophy, degeneration, increased cell pigmentation, and fatty infiltration.

5. Gradual decrease in tissue elasticity and degenerative changes in the elastic connective tissue.

6. Decreased speed, strength, and endurance of skeletal neuromuscular reactions.

7. Decreased strength of skeletal muscle.

8. Progressive degeneration and atrophy of the nervous system.

All these changes should have meaning to dentists who are treating hard and soft tissues that are connected with the stream of life and the general biologic process.

TYPES OF DENTAL DISEASE

What are the common clinical conditions that we encounter in the aged that lead to the nonfunction or malfunction in mastication? The diseases are essentially the same as those that attack other adults, namely, dental caries and periodontal disease.

Although dental caries is more active during adolescence and early adult life, there is often an exacerbation during senescence. A sizeable number of people maintain their teeth through a high index of immunity to early caries or from good dental care to enter old age and lose their teeth from the acute caries of senescence. Caries in the aged is often rapid, deeply penetrating, with early pulp involvement.

The caries of senscence may be accounted for by the decreased bacteriostatic power of the saliva and the atrophy of the salivary glands.

According to the eminent physiologist Anton Carlson[2]:

"The salivary glands usually show some evidence of atrophy with advancing years; competent investigators have reported definite decrease in *salivary volume* and in percentage of ptyalin with advance in age. This is not a vital link in the life span, for most animals have no ptyalin and we can adequately digest all our food without the aid of ptyalin, the most important constituent of saliva being the water and mucin. To what extent the decrease in saliva or the age changes in the composition of the saliva permit or favor growth of the aciduric flora of the mouth, which in turn may enhance degenerations in teeth and gums, is still an open question."

The pulp in the aged has poor resistance, and an inflammatory reaction usually leads to pulp necrosis and infection at the apex and the surrounding bone. These pulp infections and their sequelae in the elderly should be considered as serious affairs and the bacteremias attending them should have adequate medical management, both during the acute phase and at the time of tooth removal.

All observers have noticed that disease which strikes the aged is different from disease that attacks youth. In the elderly, disease is endogenous, occult, cumulative, insidious, asymptomatic, chronic, and nonimmunizing, with great individual variations. In short, an acute infection in the aged is a serious affair.

Not all the pulpitides that we encounter in the senescent are the result of the acute caries of the aged. Degenerations in the dental pulp may be of blood-borne origin. Emboli and thrombi may involve the blood vessels in the dental pulp in the same manner as they involve other organs. Pulpitis may also be of hypertensive origin. Toothache in the aged is most likely to be of local caries origin, but we should be mindful that the pain may originate from a pulp undergoing degenerative change, secondary pulpitis. Such a tooth may be hypersensitive to heat and cold and tender to the functional pressures of chewing, thus presenting the same clinical picture as a pulp involved by caries. These sensitive teeth may be troublesome for long periods of time before actual pulp death occurs. In these cases the patient protects the sensitive tooth as best he can from the thermal and pressure assaults and in so doing may vary his food selections accordingly, often to the detriment of his nutritional status.

Periodontal disease is usually a disease of middle life and of older age groups. In severe periodontal disease there is an extensive inflammatory area from which may be absorbed all the noxious chemical and bacterial products that are part of the mechanism of inflammation. As the pockets extend into the supporting tissues there is usually the superimposition of a secondary infection with suppuration. The discharge of pus directly into the mouth is a contaminant for all food that passes into the gastrointestinal tract.

It has been commonly thought that the acidity of the gastric secretions destroyed the suppurative products swallowed with food. If, however, there is a deficient acidity of the gastric juice in old age, the ability to neutralize ingested pus is lessened. According to Dedichen,[3] in a study made of the acidity of gastric juice in 110 elderly persons in apparent good health, there was an absence of

acidity in 66; 76 persons in the group showed signs of gastritis due to diminished acidity. Hemoglobin was frequently reduced, and 24 of the 110 had a red blood cell count of between 2,900,000 and 4,000,000. Dedichen makes the terse observation, "Most of the patients were toothless." We might add that they were probably infinitely better off edentulous or with good replacement dentures than they would have been if every morsel of food swallowed was bathed in pus from periodontal pockets.

EXTENT OF DENTAL DYSFUNCTION

Many aged persons, although they have some of their natural teeth, free from active caries or periodontal involvement, are in severe dental dysfunction. The teeth neither occlude properly nor do they have enough masticatory surface to prepare food for digestion. The mere presence of some of the natural teeth does not assure proper physiologic function. We have all observed older people with two or three remaining precious teeth that they attempted to use in all food preparation. These people were 90 per cent disabled or decompensated from the aspect of physiologic masticatory function. Although these people are able to sustain life in a fashion, they must be considered to be dental cripples. And dental cripples, unlike those disabled from some other forms of congenital, acquired, traumatic, or degenerative disease, are subjects for rehabilitation. It would be entirely absurd to say that dental skills as expressed through restorative dentistry can restore dental cripples to 100 per cent efficiency. These people can, however, be rehabilitated 75 to 85 per cent, which is an excellent result by any standard.

Persons who have lost their teeth and are using dentures show wide variations in functional efficiency. Some of them use their prostheses with great and fabulous skill. Others find the appliances entirely intolerable. The degree of skill used in fabricating a denture determines to an extent the efficiency of its use. This is not, however, the only criterion. The residual bony ridge, the neuromuscular tonicity, and the attitude of the patient are important determinants in proper functioning of the denture. If we are permitted to generalize, we might say that persons who lose their teeth in relatively early adult years from extensive caries are better able to use dentures than people who lose their teeth in later life from pyorrhea. In early adult life the tonus of the muscles of mastication, of the lips, and of the tongue makes for better skill for manipulating dentures. Likewise, teeth lost from extensive caries produce no unfavorable degeneration in the residual bone that supports the denture base. Conversely, pyorrhea usually produces severe resorption of the bone, both before the teeth are removed and after they are extracted. Because pyorrhea usually attacks members of the older age groups, persons who have already lost much of their neuromuscular coordination, we may expect patients who lost their teeth from pyorrhea to experience more difficulty with the manipulation of dentures.

If aging, as suggested by Korenchevsky,[4] is a major involution of the living organism with hypoplasia, atrophy, and degeneration among the most important typical features, we should expect to observe atrophic changes in the

maxilla and the mandible. This we find in both the dentulous and edentulous jaws. According to Sicher[5]: "The skeletal changes lead to a considerable change in the configuration of the residual bony ridge in the upper and lower jaws. In the upper jaw there is often a *narrowing* of the arch, in the mandible a *widening*." These changes frequently present a problem to the prosthodontist.

FORMS OF DENTAL INVOLUTION

If hypoplasia, atrophic changes, and degeneration mean changes in weight and in the linear measurements of organs and cells, that is important to denture prosthetics. It is conceivable that with the increase in the number of elderly persons in the population our denture problems will become greater. We know very little of the biology of tissue atrophy and bone resorption. We know even less of the neuromuscular mechanism at work in these cases. When cerebral accidents, whether by hemorrhage or by thrombosis, befall people we know that the finely adjusted neuromuscular balances are disturbed. Difficulties in speech, in chewing, in swallowing, and in motor functioning are common. The delicate reflex mechanism of chewing is often abolished. These people can no longer tolerate or use their dentures. If neuromuscular function returns, as it often does, the rejected denture may then be used. If function does not return to the higher cerebral centers, no amount of manipulation of the peripheral dental tissues will do good.

Digestion, Nutrition, and the Dental Mechanism.—According to Stieglitz[6]: "Recent studies point out that calcium requirements are greatly *increased* in later years. The older person needs more calcium than the young adult to maintain calcium balance. Calcium loss contributes to bone fragility. The importance of milk (as a source of both protein and calcium) for the elderly is thus once more re-emphasized. Newer knowledge of the role of protein in tissue repair (typically retarded in the aged) and in the correction and prevention of anemia, has made possible immense advances in geriatric surgery.

"Both so-called 'normal' and abnormal aging are inseparably linked with nutrition. We are today what we are because of what happened to us in our yesterdays. The older we become and the more yesterdays we accumulate, the more significant become all past experiences, both good and bad, nutritional or otherwise. The nutrition of the youth affects his health in maturity, senescence, and old age, but the nutrition of each period of life presents problems peculiar to the period. To age is to change."

It is apparent what these words should mean to dentists. If the elderly person is in calcium imbalance, bone fragility is likely. This may explain rapid bone resorption under denture bases. If the elderly is suffering from hypoproteinemia, tissues do not repair following extractions. With the newer knowledge of nutrition we must approach many of our denture problems among the aged. What many of them need is not new dentures but a new mode of living that includes a complete change in patterns of food selection. Nor should we forget that the

most nutritious food available is of little consequence if the first process of digestion, namely, food preparation in the mouth, is inadequate.

In support of this point of view, Greene, Dreizen, and Spies[7] recently reported a study made among 446 carefully selected patients in a nutrition clinic. Two hundred and sixty-eight of these patients were edentulous. Of this number 219 had ill-fitting dentures, oral conditions which prevented the efficient use of dentures, or only one or no artificial dentures. Of the 178 dentulous patients, 82 had fewer than 3 occluding anterior and posterior teeth and no functional prosthetic replacements for their missing teeth. These investigators conclude: "These observations support our hypothesis that an intimate relationship exists between impaired masticatory function (masticatory insufficiency) and general nutritive failure."

O'Rourke,[8] in a comprehensive study of biting strength, drew these conclusions: "Many foods that are essential for adequate nutrition will present difficulties in mastication to a person with low tolerance to biting stress. He will attempt to make adaptations to this deficiency, but unfortunately the commonest compensations are apt to be detrimental. They include swallowing of larger or coarser food masses, and choice of softer foods. Such changes may lead to malnutrition, especially among elderly persons."

SUMMARY

To summarize, the first process of digestion and, thereby, of nutrition takes place in the mouth. The food mass is broken down into smaller parts by the mechanical action of the teeth to permit easier attack by the digestive juices, including the saliva. The act of chewing is part voluntary and part reflex. The person wills to chew, but the power of the chewing stroke is determined by neuromuscular tonus and the condition of the dental tissues. The pressure that is exerted and the extent of the chewing stroke is a reflex act determined by the character of the food bolus and the presence or the absence of dental pain or discomfort.

If the first step in digestion, namely, the mechanical preparation of the bolus, is inadequate it is conceivable that the succeeding steps in digestion will suffer. The chewing of palatable food stimulates the flow of gastric juice. In the case of the aged, inadequate mechanical preparation of the food results from painful, nonfunctioning, or missing teeth, or from unsatisfactory dentures. When mechanical preparation is difficult or painful, the person begins to select foods to conserve effort or to diminish pain. By this pernicious process of self-selection he may gradually drift into the state of malnutrition.

An opportunity is open for a piece of enterprising research on the application of gerontology to the dental problem. Without adequate nutrition the aged patient cannot long edure. Adequate nutrition is impossible in the face of disturbance along the digestive tract. The mouth is the beginning of the digestive system. Its structures and functions have long been neglected in the consideration of the nutritional problems of *all* ages. The French have told us that "death enters through the mouth." We might likewise say that so, too, do life, and health, and long well-being.

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THE NEGLECTED FACTOR IN DENTURE SERVICE

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DURING the last few years, I have been interested in finding the answer to this question: "With what kind of denture patient is a dentist most likely to succeed, that is, achieve satisfaction both for the patient and himself?"

If the determinant factors of denture building were divided into two aspects, which would contribute more to the result—a favorable patient attitude or a favorable oral and ridge condition? Conversely, if one or the other appears unfavorable, which one will be the greater hindrance to the success of the case? Experience appears to justify the following conclusion: "The patient with whom a dentist is most likely to succeed is the patient with the proper attitude toward dentures." If this is the case, an analysis should be made as to what constitutes a proper attitude and how it can be nurtured.

Dentists with recognized ability in construction will agree that good technique means little for a patient with an improper attitude. Then, action should be taken to improve an improper attitude. Even a neurotic attitude can be adjusted by careful guidance if it is not too advanced. Like psychiatrists, who take a long period to straighten out neurotic patients, dentists must also take some time. If time is one of the elements required to achieve the proper patient attitude, it is essential that that time be made available.

But, you ask: "How can an exacting dental technique and a lengthy mental rehabilitation discussion with your patient be afforded for the average amount of pay?" In reply, it should be pointed out that denture work receives better compensation per hour than most phases of dentistry. In addition, ten hours of chair time is ample for technical procedures, including the time spent in mental rehabilitation discussion. The average fee is also ample to permit the use of this amount of time.

In order to allot required time to denture work, and to avoid grief, dentists must be made aware of certain tricks which we play upon ourselves without our realizing it. Too frequently, fifteen-minute appointments are inserted between patients in order to keep the total time spent on a denture case within, let us say, three hours or less. Too often a dentist races himself into a frenzy trying to produce an excessive hourly rate on denture cases. Unfortunately, when this jackpot is occasionally attained, the dentist is encouraged to re-play the unhappy game. However, to hit the jackpot on a set of dentures, an amiable patient, who is easily satisfied, is required. He is one of the very few who will wear atrocious-looking and ill-fitting dentures. Since there are so few of this type and we do not know how to find and recognize it, we cannot continue to gamble.

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It follows then, if we dentists are to be happy and prosperous, our patients must be carefully selected and enlightened. We can and must select our dental patients, just as they select us. It is an error to proceed immediately on all patients who express a desire to have good dentures constructed. A person may come to your office merely because he has heard that you will accept "half-payment" for a "try" on solving his psychologic riddle with his edentulous mouth. And the fact that a patient presents a personality problem is difficult to detect in a short interview. Mouth difficulties presented by a patient are simple to solve as compared with the psychologic puzzles presented. A helpful factor, however, is that almost every patient is willing to have his mental attitude problem discussed and difficulties revealed to him. He will admit their existence when he is carefully approached and questioned in advance of the start of construction. No patient likes explanations after the case has been completed, because they then sound like alibis and poor excuses.

If an hour is required, then an hour should be spent in talking with and analyzing the patient before beginning work for him. A definite plan should be followed in questioning the patient. There are certain questions that should be asked, and there are some answers that the patient can be expected to give.

Some of these questions should be: "How is your general health?" "Are you a nervous person?" "Are you cheerful and easy going?" "Do you worry much?" "Are you easily upset?" "Are you persistent and persevering?" "Are you easily discouraged?" "Do you learn to handle new things easily, such as bifocal glasses?" "How long have your teeth been missing?" "How long have you worn old dentures, if you have worn them?" "Did you like your former dentures?" "In what way did they trouble you?" "Why do you want new ones?" "Did you quarrel with your dentist?" "Did you quarrel with your dentist over payment?" "Do you think the lower denture as good as the upper denture?" "Do you know anyone with successful complete dentures?" "Do you know anyone who has been unsuccessful with them?"

To the question, "What do you expect of a set of dentures," one of the answers that the patient may give is: "Oh, I only want something that stays in place, fits well, looks good, that I can eat with, and doesn't make my mouth sore." What the patient expects sounds fairly reasonable to the patient. However, even to an experienced dentist, the task may be insurmountable. Then, too, what one patient may think its a good fit in dentures is an abominable one to others. The word "fit" is a very relative term. As a result of these questions, one should have ascertained whether or not the patient has a favorable attitude. Some of the indications that he is a favorable risk are: that he has worn his old dentures successfully; that he is not neurotic; that he accomplishes a new venture in learning; that his expectancy is normal; that he has persistence and perserverance; that he realizes that an artificial substitute has limitations; and that he has the attribute of average reasonableness.

Following the questioning stage, it is now important to discuss the limitations of an artificial substitute and the inherent difficulties. A patient with the right attitude accepts these remarks. The excitable, exacting, and unreasonable type is

DENTURE DIAGNOSIS, PROGNOSIS, AND TREATMENT PLANNING

PATIENT..... STUDENT..... CHART NO..... DATE.....

A. Health
   1. General health.....
   2. Muscle tone.....
      Bone structure.....
   3. X-ray interpretation for retained root tips and residual infection and bone density .....

B. Age.....

C. Sex.....

D. Occupation.....

E. Mental attitude
   1. Expectancy
      a. Normal.....
      b. Overexpectancy.....
      c. Pessimistic.....
   2. Indifferent.....
   3. Supercritical.....
   4. Nervous.....
   5. Adaptability
      a. Awkward.....
      b. Average.....
      c. Capable.....
   6. Family and friend's influences.....

F. Esthetic opportunity
   1. Lip length and thickness.....
   2. Position of anterior teeth.....
   3. Position of posterior teeth.....

G. Edentulous history
   1. Immediate restoration.....
   2. Under 3 weeks.....
   3. Under 3 months.....
   4. Over 1 year.....
   5. Old denture wearer.....
      a. Type of denture worn.....
      b. Old result satisfactory.....
      c. Old result unsatisfactory.....
         Why.....

H. Ridge shape (aveolar bone shape)

1. Undercut	U.....	L.....
2. Full and bulging	U.....	L.....
3. Parallel sided	U.....	L.....
4. V-shaped	U.....	L.....
5. High	U.....	L.....
6. Low ridge (flat)	U.....	L.....
7. Narrow	U.....	L.....
8. Broad	U.....	L.....

I. Intermaxillary space
   1. Favorable.....
   2. Small space.....
   3. Large space.....

J. Size of bearing area

1. Large	U.....	L.....
2. Average	U.....	L.....
3. Small	U.....	L.....

K. Ridge relations
   1. Normal.....
   2. Prognathus.....
   3. Orthognathus.....
   4. Cross-bite A.....
   5. Cross-bite B.....

L. Face form (front and profile).....

M. Zygomatic process
   1. Above border.....
   2. Average.....
   3. Very low.....
   4. Unyielding mucosa over zygomatic process.....

N. Maxillary palate shape
   1. High.....
   2. Average.....
   3. Low.....
   4. Torus palatinus
      a. Average width.....
      b. Broad.....
      c. Low bulging.....
      d. Narrow.....
      e. No torus.....

O. Tuberosities
   1. Large.....
   2. Med.....
   3. Small.....

P. Buccal space
   1. High.....
   2. Average.....
   3. Low.....

Q. Soft palate form
   1. Wide post dam area.....
   2. Average post dam area.....
   3. Very narrow post dam area.....

R. Soft tissue conditions

1. Normal depth	U.....	L.....
2. Hard unyielding	U.....	L.....
3. Soft and spongy	U.....	L.....
4. Inflamed due to old dentures	U.....	L.....

S. Mucobuccal fold

1. High	U.....	L.....
2. Low	U.....	L.....
3. Medium	U.....	L.....

T. Muscle attachments

1. Maxillary frenum.....		
2. Maxillary buccinator	R.....	L.....
3. Labial mandibular frenum.....		
4. Mandibular buccinator	R.....	L.....
5. Lingual frenum.....		
6. Mylohyoid	R.....	L.....

U. Muscular tone of muscles of expression.....

V. Muscular development (muscles of mastication).....

W. Tongue size.....

X. Condition of saliva
   1. Thick-ropey.....
   2. Normal.....
   3. Thin.....
   4. Quantity.....

Y. Result of check-up after.....months

apt to object. If he does refuse to accept these facts, now is the time to come to an understanding; otherwise, it is the time to eliminate him from further consideration.

It should be pointed out that, on the average, a person requiring a third set of dentures is likely to be neurotic, and to construct another denture may be an unprofitable adventure. The failure of a patient to wear his former restorations may be justified and yet, without careful handling, this patient may start a worrying and frustration spin that neither you nor he can stop. Although the patient arouses sympathy, he is, nevertheless, an office headache and a loss. Often, a person of this type is a respectable man who needs to be made aware of the psychologic and pathologic aspects of his problem, and the fact that dental science and art cannot alleviate it completely.

Furthermore, it seems unfair for the dentist to shoulder all the blame for people becoming edentulous cripples. No one has maliciously knocked out their natural teeth. Many people think that if they pay you a fee, the problem becomes all yours. They say, in effect, "Here is the problem; what do you want to do about it?" The dentist should be careful not to accept the responsibility of the *entire* problem. In other words, the problems of the patient's mouth still belong to the patient.

In considering the effectiveness of various artificial replacements for loss of natural parts of the body, a leg, an arm, an eye, the dental profession with the artificial denture has probably developed the best-appearing and most functional substitute. And we should not apologize if some difficulties still remain after restorative work has been done. Overexpectancy and a poor attitude on the part of the patient can hinder the success of a well-constructed case.

To remind ourselves of the many factors involved in the construction of a set of dentures, a chart should be made of the diagnostic limitations similar to the chart illustrated.

It is not sufficient merely to hold conversation with the patient regarding the limitations of artificial dentures. A copy of some printed instructions and information should be given to the patient in order to have an understanding of what can or can not be accomplished for him. This information is, in effect, an agreement, a copy of which should be kept in the patient's possession.

INFORMATION AND INSTRUCTIONS FOR DENTURE PATIENTS

The great improvement in recent years in the natural appearance of the individual artificial teeth, as to size, shape, and color, plus the lifelike gum material, have removed the feeling of dread that was attendant upon the wearing of new dentures. However, it is foolhardy to believe that everything is simple and easy regarding the change from natural teeth to artificial substitutes. However, dentures constructed today are more efficient and cause less distress than those made in former years.

The most important consideration for anyone facing any loss of his natural teeth is whether all or only part of them must be lost. Removing all natural teeth, especially the lower ones, is to be avoided if possible. Retaining a few teeth in the right places may result in years of greater comfort and better appearance. A partial denture is more useful than a complete denture and serves as a splint to aid the remaining natural teeth. These remaining teeth

prevent the movement of the replaced teeth that is often associated with a full or complete lower denture.

Choice of the Type of Denture.—If a complete upper or lower denture, or both, are to be made, the patient and the dentist must decide on the type of procedure. Is it to be the old regular way of removing the teeth and waiting a few weeks or months for healing before building the case, or is it to be the immediate denture method that places the new denture in the mouth at the time the remaining front teeth are extracted? If the immediate type of procedure is chosen, it is not necessary to have a full complement of front teeth. There are advantages to be gained if only one cuspid, or any front tooth, remains in the upper arch, because an exact duplicaton of position of that tooth in relation to the head enables us to orient the front teeth for their vertical position, for their front-to-back position, for arch width, and so forth, because the opposite cuspid can be set in a symmetric relation to the remaining cuspid, and then the four incisors can be placed in harmony with the two cuspids. In this manner, the positions of all front teeth have been re-established more correctly than would have been possible without the clue of the one remaining cuspid. Therefore, it becomes obvious that there are advantages in having the whole or any part of the front teeth as a guide to repositioning correctly the artificial teeth.

There are advantages and disadvantages to this form of construction.

The Advantages of Immediate Insertion.—

1. The patient does not need to go through the humiliating toothless period of healing. This is especially appreciated by a person in business or one conscious of social prestige.

2. There is usually less pain because the denture acts as a protecting splint for the open wounds and thus aids healing. The patient is recovering from the shock of a surgical operation and learning to manipulate dentures at the same time. In the old regular denture procedure, this pain and inconvenience must be endured in two separate stages.

3. Appearance is less affected, because there is less change in muscle and supporting structures and the jaw opening is maintained.

4. The patient is not so likely to jeopardize his health by retaining infected teeth too long, because there is less dread of a complete denture or the toothless period usually associated with the ordinary construction of dentures.

5. There is likely to be more lasting stability and better tissue resiliency. Toothless mouths without a protective covering lose tissue softness, and bone resorbs more rapidly without the necessary stimulation, supplied by the denture base, for functional rebuilding.

6. There is less difficulty in repositioning the surrounding structures. This fact is shown by the tongue's spreading because of lack of contact with the teeth, and by the cheeks' falling in when the patient is without teeth for a great length of time.

7. The greatest art is to conceal art, and this is possible in immediate dentures by placing the teeth in their former identical positions. Therefore, it is possible to have the same dental arch contour, the same dental arch position, the same size and shape of the teeth, and the same individual rotational positions and inclinations that the natural teeth possessed.

The Disadvantages of Immediate Insertion.—A careful consideration of the difficulties and disadvantages is necessary in order to assure success and satisfaction to the patient and to the dentist. The patient should be *prepared to meet the additional expense and time involved.* A rebase or duplication is usually necessary *within a few months. This additional work should be understood in advance, or the dentist and patient are apt to have some misunderstanding when these changes become necessary.*

The picture of immediate denture construction is not as simple as has often been painted, because the number of office visits is increased by the necessity for watching, for the first few months, the changing bite, due to the uneven shrinkage of the mouth.

Results To Be Expected.—Satisfaction in complete dentures depends upon so many factors that no two cases ever have quite the same outcome. Much depends upon the personal

attitude. A proper understanding of this artificial substitution makes the solving of the problem easier for all concerned. One cannot expect too much, too fast, in spite of the advance in this science and art. Results depend upon temperament, age, health, shape and size of mouth, length of time teeth have been missing, how much the patient expects, as well as the skill, knowledge, and material used in construction. No two patients are alike; therefore, no two results are alike. The dentures can be built no better than the foundation of each individual case.

The lower denture is seldom equal to the upper, either in ability to remain in place or to withstand biting pressure. The lower has only a rim to grip and rest on, with the tongue to disturb it, while the upper has the entire roof of the mouth, free from interference.

Shrinkage and Relining.—The idea that dentures can remain permanently satisfactory is a mistaken one. Under the influence of saliva and other fluids, the materials deteriorate. The supporting bone and tissue undergo constant change. This change continues throughout life, although the greatest change takes place in the first six months. To maintain full use and appearance, the case must be altered to meet these changes, or a new case constructed. The cost of alteration is not part of the original charge any more than the upkeep and replacement care of a car is part of its original cost.

Learning Time.—The patient usualy talks quite well immediately, and he improves with practice. Learning to eat well may require many months of practice. The patient should be instructed that, during a two-day period, mastication of food may be attempted on simple types of food, such as crackers, soft toast, chopped meat, etc., but that no attempt should be made to handle food at the table. During the learning period of mastication, the patient is advised to be away from critical observation of friends or of members of the family for it is expected that he will be awkward in the beginning and susceptible to embarrassment and resulting discouragement. Kindly but misplaced joking remarks and comments by members of the family may readily lead the patient to a denture-conscious complex that will be reflected in his attitude toward the dentist and the denture

The patient must be carfully advised that the esthetic effects will not be the best at the start. The lips have not yet adapted themselves to the fullness of the denture borders and arches and may present a distorted appearance that will smooth out with time. Muscle tension may cause an awkward look that will adjust itself after the patient becomes relaxed and more self-confident. The patient should be instructed to refrain from an early exhibiting of the dentures to his curious friends until he is confident and competent to exhibit them at their best. If the patient is not careful in following these instructions, he will become unfairly critical of the dentures and develop an attitude which will be difficult for the dentist to overcome. During the edentulous or partially edentulous period of time, a gradual closure of the bite and collapsing of the lips will have occurred. The collapse of the face has usually been so gradual that the family and friends of the patient have not been aware of it. Therefore, the complete change of repositioning the lips by a restoration of former facial dimension and contour may seem too great a change in the patient's appearance. This sudden change may come to the patient and family as a shock, because they have forgotten the former appearance of the patient. This can be overcome only with the passing of time, and the patient is advised to persevere during this period of readjustment.

The mouth was not intended to bear the stresses of mastication by artificial dentures. Therefore, the patient, especially if his general health is somewhat impaired, may expect some irritation and discomfort of the oral tissues. No two patients' mouths will react alike because some tissues will tolerate stress better than others and, therefore, the expectancy in this respect cannot be exactly predicted. The patient should be advised of these varying and unpredictable conditions. If some irritation of the tissues is experienced during this two-day period, the patient is advised to remove the dentures and rest the mouth for a time. More harm than good is done by telling the patient he must keep the dentures in the mouth constantly during this period because the patient will become highly nervous and fatigued, with

a resulting unnecessarily discouraged attitude toward the final wearing of the dentures. It is better to tell the patient that progress will be gradual and that he should not necessarily expect to master the use of the dentures in a short time.

People from 20 to 30 years of age can learn to handle dentures in ten days, while those from 30 to 40 need nearly three weeks and those from 40 to 50 often take two or three months and those in poor health may be a year before becoming unconscious of their presence. However, everyone should be better the second week than the first, and continued progress is all that is necessary. The more adaptable a person is the more readily he becomes adjusted to complete dentures.

Care.—New dentures may be left out of the mouth for short rest periods. Once the patient has mastered the use of his dentures, they should be left out at night, or at some time, to give the blood circulation an opportunity to rebuild the tissues of the bearing area.

Constant wearing of dentures without proper brushing causes soreness and additional shrinkage. They should be brushed daily with a soft brush and soap. This should be done above water, so they will not break if dropped. Especial attention should be given to cleanliness inside clasps of partial dentures, and to the natural teeth which the clasps contact. If these areas are not kept polished, decay is sure to result. The remaining natural teeth should be checked and cleaned every six months, and any necessary fillings placed, if there has been decay.

The patient who gives his dentures the care and upkeep which any mechanical device should have will receive maximum comfort and usefulness from them.

Consideration of the problem of the patient's attitude and readjustments of his mental state takes some time and, unless recognized and appraised, can take the joy out of our work. Much of the grief can be alleviated by carefully screening patients and either improving their attitude or declining to proceed further. When a critical analysis of the patient's questionable attitude is made, the decision must also be made whether or not he is amenable to change and, if not, it is best for the individual's sake and the dentist's sake not to start or continue the case.

I hope this discussion has shown that patient management and psychologic factors in prosthetic dentistry have been neglected; that a proper patient attitude is as necessary to the successful building of dentures as good technical procedure; that much can be done to improve the patient's mental condition regarding the wearing of dentures.

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THE PROSTHODONTIST'S RESPONSIBILITY IN THE CONTROL OF CANCER

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THE cancer problem treats with the research on and the diagnosis and treatment of malignant diseases found in the human race. There are many types of this disease, and they present varying symptoms and clinical characteristics; however, all of them are essentially a disease in which there is an unrestrained and independent growth of cells which not only lack healthy function, but destroy cells which do have a healthy function.

We as dentists are primarily interested in the manifestation of this disease in the mouth. It is of interest to note that most every type of cellular structure is found in the mouth and consequently most every type of this disease is found within the oral organ.

The causes of human cancer are unkown; however, from the mass of statistical data that has been accumulated, we find several significant factors which are of value to the clinician:

1. The incidence of cancer increases rapidly with the increase of age past the middle-age group.

2. There is a definite increase in five-year cures of cancer of the mouth if adequate treatment is instituted early in the disease.

3. The cellular reaction to prolonged irritation appears to be a predisposing factor in the cause of cancer.

The diagnosis of early change of normal cells to malignant ones is very difficult because there are no symptoms to guide us in its detection. This difficulty will probably remain with us until a specific test for cancer has been developed, such as the Wassermann test for the detection of syphilis. The inability to recognize early cellular changes makes for serious trouble in cancer therapy because the disease may soon change from a localized to a generalized one. At the present time the only reliable means of cancer detection we have are the physical examination and the microscopic study of the biopsy section.

I believe we are all in agreement that a complete oral diagnosis should be made before any prosthetic restorations are attempted. The armamentarium for this diagnosis should include a history of oral ailments, their treatment and results of treatment, a complete x-ray map of the mouth, a thorough digital and visual

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examination of the tissues of the mouth and face, and a careful investigation of the lymph nodes which drain this region. It is extremely important for the prosthodontist to be ever on the alert to discover suspicious tissue changes in the digital and visual examination. Only by continued vigilance will you be fulfilling your responsibility in the control of cancer.

The most reliable means of evaluating suspicious tissue changes is to remove a part of the tissue for microscopic study. However, there are certain characteristics of malignant growths found in the region of the oral organ which are of great value in making a differential diagnosis. The most significant ones are:

1. A history of an unhealing soft tissue lesion or extraction site for a period of weeks or months.

2. The lesion is usually painless to palpation.

3. There is induration around the ulceration.

4. There may be papillary outgrowth even though there is considerable ulceration present.

5. The margin of the soft tissue lesions may have a rolled pearly appearance.

6. After the growth is well established it is usually fixed to the underlying tissues.

7. The x-ray findings of lesions involving the bone will show in the majority of cases a destruction of bone, but in a few cases, particularly the sarcomas, an increase in density of the bone may be shown; however, they are both characterized by indistinct and irregular borders.

The biopsy section is not only important in making the diagnosis of a cancer but in many cases it determines the type of treatment which is most likely to be successful. To be of the most value the following rules should be followed in taking a biopsy section from the mouth:

1. The section from the soft tissues should be taken with a sharp knife and sections from the bone should be taken with a sharp chisel.

2. It should include tumor as well as normal tissue. This is easily done by making an eliptical incision through the border of the tumor.

3. Care should be taken not to crush or mutilate the specimen.

4. After the removal of a section of tissue it should be immediately placed in a fixation solution. Zenker's acetic or Zenker's formal solution are preferred by most pathologists; however, the pathologist in the community will supply the prosthodontist with small specimen bottles containing the fixation solution he prefers.

5. All specimens must be labeled with the patient's name, address, age, and date obtained.

6. A short history of the lesion and a statement of its location and clinical appearance should be sent to the pathologist with the section of tissue.

The actual surgery involved in the removal of the biopsy section is not a serious matter. However, the responsibility the prosthodontist assumes is a serious one

for then it becomes a legal responsibility as a member of the health service to see that there is a follow-up on the biopsy report. If it is positive for cancer, the prosthodontist is held responsible for advising the patient to seek immediate treatment for his disease.

Even with a negative report from the pathologist, it is wise to insist on consultation on unfamiliar lesions. We are all familiar with the type of patient who refuses to take advice for consultation on a symptomless lesion. However, for protection it is well to have a written memorandum in the prosthodontist's files of his advice to the patient and signed by the patient.

In order to bring to attention more forcefully the responsibility we have in the early diagnosis of cancer, I would like to restate several points already discussed in this paper.

1. The diagnosis and adequate treatment must be done early in the disease if we are to do any more than just palliation for our patients.

2. The majority of these lesions are found in the older members of our society.

3. The early malignant tumors usually present no serious symptoms.

4. If one attempts the treatment of any lesion, he assumes the moral and legal responsibility for a complete diagnosis and treatment by his own efforts or by referring the patient to other men in the health service.

The significance of these findings is simply this: Many of the older age group are in a symptomless state of general health, but are edentulous or at least they have lost enough of their dentition to make proper oral function impossible. Consequently, the only professional health service they receive is from the prosthodontist. Furthermore, this group of patients usually continue to neglect regular physical examinations, so the professional man who places the denture prosthesis not only has the responsibility of observing routinely the function of the dentures, but he should take the opportunity to search for suspicious tissue changes in the region of the mouth and face.

In the actual treatment of malignant lesions our professional services are required in several important procedures. The first one I would like to call to attention is the therapeutic radium holder. Although it is not the purpose of this paper to discuss the various types and techniques of fabrication, I believe we all should be familiar with the three basic principles involved in their construction. If these principles are followed the radiologist may be most accurate in his calculation of the proper dosage.

1. The therapeutic radium holder should be made of metal, preferably lead, and should be designed in a manner that will protect the osseous structure from the radiation. The thickness of this protective wall is governed by the space available.

2. The box which is to hold the radium over the lesion should be large enough to allow for proper spacing of the radium.

3. The appliance should have a definite anchorage so it may be removed and replaced with accuracy.

The second procedure I would like to emphasize is that of oral hygiene. It has been conclusively shown that heavy therapeutic dosage of radiation lowers the resistance to infection of all normal tissue, and particularly that of the bone structures. So if we are to avoid the postradiation hazards of infection in the tissues of the mouth, it is absolutely essential that these tissues are protected by proper mouth cleansing. In addition to this I believe it is good treatment to remove the teeth from that part of the alveolar process which will be directly exposed to the effects of massive doses of radiation. This I feel is a justifiable procedure because the edentulous alveolar ridges covered with a well-healed membrane is more resistant to infection. Also, if teeth are left in the area and it becomes necessary to remove them later, there is considerable danger of osteoradionecrosis involving the bone which is very resistant to treatment.

The third responsibility in the treatment of oral malignancies is the diagnosis, designing, and fabrication of appliances, the purpose of which is to restore function of the tissues lost by surgery. The majority of these patients with large surgical defects are in the older age group, and because of the multiple time-consuming procedures necessary to close the defects by plastic surgery, and the inability of these patients to withstand this extra surgery in comfort, the method of choice is the prosthetic appliance.

In the field of research on this problem we of the dental profession should be continually searching for materials and appliances which will restore the normal physiology of diseased mouths and which, at the same time, will be nonirritating to the tissues. Also, carefully recorded observations of the results of our treatments in correlation with the general metabolic behavior of the patient may be of aid in lifting the iron curtain which surrounds the truth of cell physiology.

In conclusion I wish to say that this paper has been presented in an attempt to show that the cancer problem is not alone the responsibility of the few who are specializing in cancer research and treatment, but that all members of the health services are obligated. Those who do prosthetic dentistry have responsibilities in all phases of the problem.

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FACIAL TYPES AND TOOTH ARRANGEMENT

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THE importance of esthetics as a fundamental requirement of modern denture prosthesis certainly needs no elaboration. Unfortunately, the ability to establish a harmonious relationship between the artificial teeth and alveolar ridges in their proper relation to facial harmony is not readily acquired.[1] To date those men who have achieved the best esthetic results probably started with a natural sense of harmony, a high degree of interest, great powers of observation, and a photographic memory for facial types or characteristics. Unfortunately, relatively few individuals are so well endowed. The average prosthodontist achieves esthetic qualities largely by trial and error, experience finally being gained from an observation of past mistakes. Teaching of facial harmony and the relationship of tooth arrangement to facial harmony has always been one of the weak spots in prosthetic curriculum. The difficulty is enhanced by the indefinite nature of the subject and by the dearth of available reference material. A review of the literature on the subject will reveal that, compared with other phases of prosthetic dentistry, relatively few articles have been written on the subject of esthetics. Most of the material which has been published gives valuable information, but largely by inference rather than by concrete facts. These articles can best be appreciated by practitioners who have acquired a clinical background, but they are of little value to undergraduate students. In the teaching of undergraduates, the direct approach to any problem is essential, this now being particularly true due to our crowded dental curriculum and the methods by which our students have been trained in their preprofessional years. If we are to improve the teaching of esthetic factors, some sort of a systematic approach must be developed by which available information may be classified and studied. If the pertinent facts may be classified, such material may then be presented to students as concrete information. An adequate classification of facial types must be used as a foundation upon which any pertinent or factual data may be supported. Confusion reigned supreme in the matter of tooth selection until Williams[2] classified human faces into three typal forms, namely, square, tapering, and ovoid. This basic classification was of value, but its value has been greatly enhanced by the addition of some six combination typal forms by House and Loop.[3] Harmony between tooth form and facial types has long been recognized. However, the student still finds that it is one thing to select the correct tooth and quite another matter when he attempts to set the teeth in their proper relation to achieve facial harmony. When teeth are to be set in proper

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relation to achieve facial harmony, the type of facial profile must be taken into consideration. To date, the classification of facial profiles most commonly used has been limited to three general types, namely, the straight or normal, the convex or orthognathic, and the concave or prognathic. Most authors on the subject of esthetics and tooth arrangement use this extremely simple classification of facial profiles and merely mention that the anterior teeth should be arranged in harmony with the profile.[4] To the student or to the practitioner this classification is of little practical value as concavity or convexity of a profile may be caused by a number of different anatomic variations. For example, a convex profile may be caused by an overdevelopment of the maxilla, an underdevelopment of the mandible, or a combination of both. An arrangement of teeth harmonious to one type of convex profile, therefore, could not apply to all types. If we are to analyze a facial profile from the structural standpoint, the Simon classification is of much greater value than the simple, three-group classification previously mentioned and commonly used. Simon,[5] a German orthodontist, presented his classification of facial profiles as a part of a system of diagnosis and treatment for orthodontic cases. The Simon classification is based upon anthropologic landmarks or their facial equivalents which may be readily located. As the landmarks are situated outside of the area of change occasioned by or following the extraction of natural teeth, this classification is suitable for use by the prosthodontist. The primary objective of Simon's work was to achieve a scientifically correct diagnosis of facial anomalies in order that a proper type of orthodontic treatment might be instituted, the objective of the treatment being to bring all cases as near to the ideal or norm as possible. As prosthodontists, we occasionally wish to correct or minimize facial anomalies, but many of us recognize that a number of so-called anomalies are distinctive facial types rather than mere deviations from the norm. Whether the cause of some of these anomalies is due to the nutrition and physical degeneration or due to a blending of racial types is a matter for anthropologic speculation.[6,7] If we will accept these more common types, not as correctable deviations from the norm, but as individual types, we may then analyze them and attempt to correlate the arrangement of teeth with the facial contour, if and when harmonious relationship exists. With this concept in mind a study of facial types presenting harmonious natural dentitions, grouped in accordance with the Simon classification, has been attempted. As was previously mentioned, the Simon classification is based upon relationship of anthropologic landmarks. The landmarks used may be explained briefly as follows:

1. Cheilion — Corner of mouth
2. Orbitale — The lowest point of the bony orbit; may be readily palpated and marked on the living subject. It is approximately below the pupil of the eye
3. Tragion — The rounded eminence anterior to the external auditory meatus, the superior border of which is approximately on the level with the superior margin of the external auditory meatus

4.	Gnathion	The lowest and most anterior point on the body of the mandible
5.	Gonion	The angle of the mandible at the junction between the body and the ramus
6.	Nasion	Taken at the deepest point at the bridge of the nose; actually it is the junction between the frontal and nasal bones at the nasofrontal suture
7.	Subnasion	Point of junction between the nasal septum and the upper lip
8.	Eye-ear plane	The plane passing through orbital points and the tragion. This is comparable to the Frankfort plane
9.	Orbital plane	A plane passing through the orbital points at right angles to the eye-ear plane
10.	Nasion line	A line dropped from the nasion running parallel to the orbital plane

The classification proposed by Simon consists of five major groups: (1) norm or normal, (2) protractions, (3) retractions, (4) attractions, and (5) abstractions.

Protractions and retractions are primarily horizontal deviations from the normal whereas the attractions and abstractions are vertical deviations from the normal. Protractive and retractive groups are subdivided into maxillary, mandibular, and maxillomandibular (bimaxillary) types. The mandibular retractive group are further subgrouped into (1) lower alveolar retraction, (2) vertical mandibular retraction, (3) horizontal mandibular retraction, and (4) total mandibular retraction (Fig. 1).

THE NORM OR NORMAL TYPE

The norm as proposed by Simon is a straight or flat profile type with the orbital plane passing through the cheilion and the gnathion, the subnasion lying between the orbital plane and a line dropped from the nasion parallel to the orbital plane. The face is composed of equal thirds, that is, the distance from the hairline to the nasion and the distance from the nasion to the subnasion and the distance from the subnasion to the gonion are approximately equal in length. Also, the distance from gnathion to gonion is approximately equal to the distance from gonion to tragion (Fig. 2).

PROTRACTION

A maxillary protraction exists when the subnasion lies anterior to the nasion line, all other landmarks being normal. A mandibular protraction exists when the gnathion lies anterior to the orbial plane, all other landmarks being equal. A bimaxillary protraction exists when the subnasion lies anterior to the nasion line and the gnathion lies anterior to the orbital plane, other landmarks being normal.

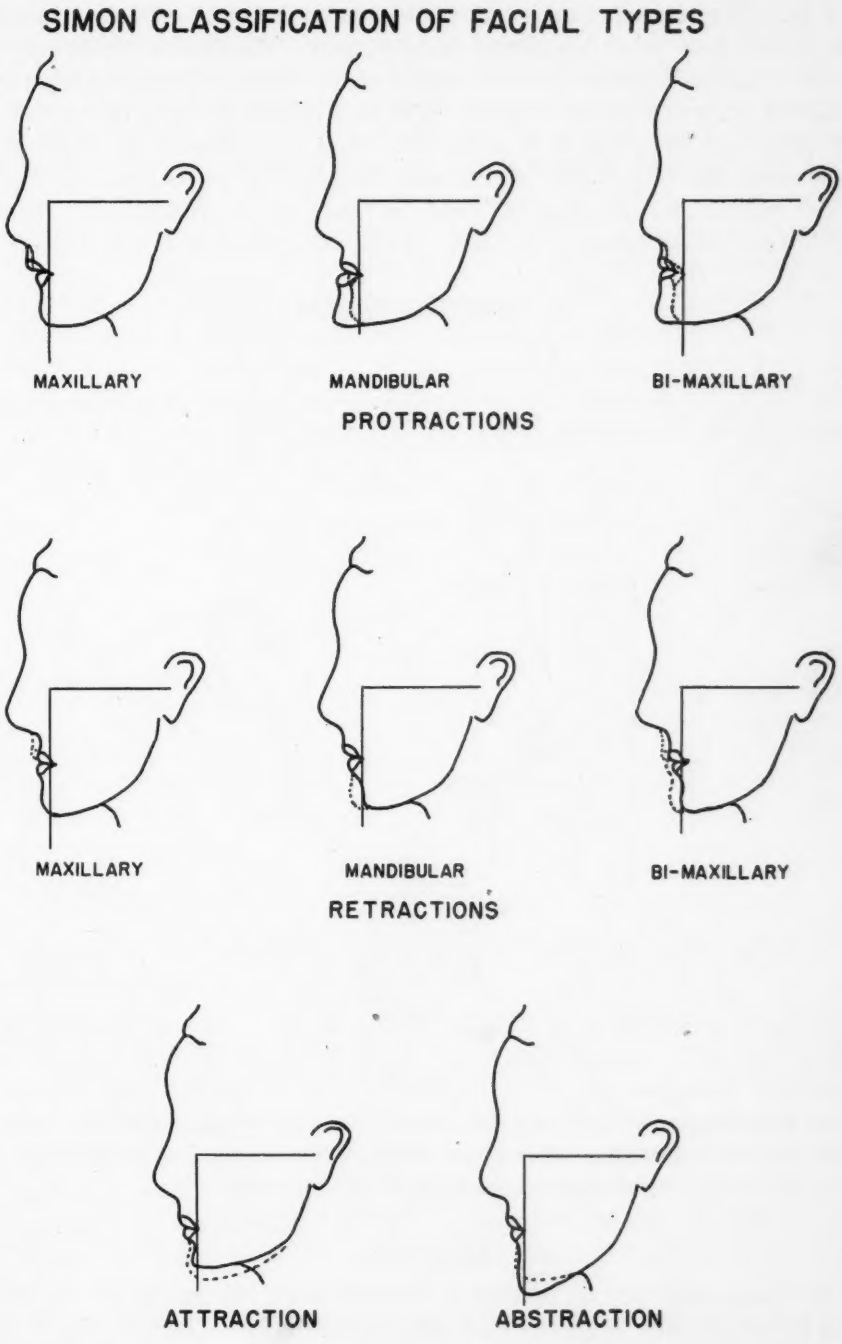
SIMON CLASSIFICATION OF FACIAL TYPES
MAXILLARY
MANDIBULAR
BI-MAXILLARY
PROTRACTIONS
MAXILLARY
MANDIBULAR
BI-MAXILLARY
RETRACTIONS
ATTRACTION
ABSTRACTION

Fig. 1.

RETRACTION

A maxillary retraction exists when the subnasion lies close to or is posterior to the orbital plane, other landmarks being normal. Mandibular retraction exists when the gnathion is posterior to the orbital plane, other landmarks being normal. Bimaxillary retraction exists when the subnasion is close to or is posterior to the orbital plane and the gnathion is posterior to the orbital plane. In classifying individual cases, the relationship of the teeth, the alveolar process, and the body of both the maxilla and the mandible must be taken into consideration. Also, the relative length of the ramus to the body of the mandible is of importance.

SIMON'S NORM

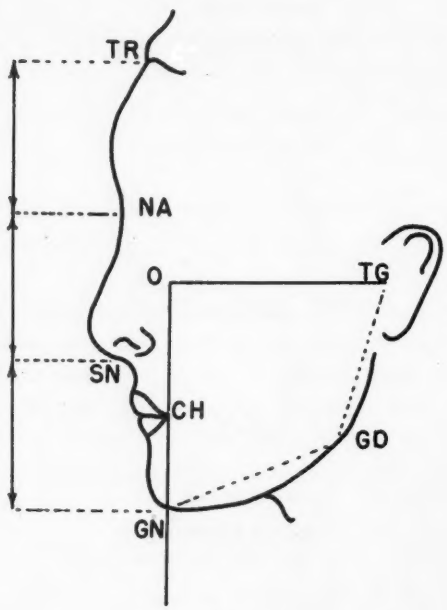

Fig. 2.

ATTRACTION

An attraction may be considered to exist when the distance from the subnasion to the gnathion is less than other facial thirds. The shortening of the lower third is primarily from the cheilion to the base of the mandible.

ABSTRACTION

An abstraction may be considered to exist when the distance from the subnasion to the gnathion is greater than other facial thirds. The excessive length of the lower third being from cheilion to gnathion.

The following material is based upon photographic and cephalometric records of 105 students at the University of California. The individual cases were selected on

the basis of a harmonious relationship between tooth arrangement and facial type. The facial landmarks used for measuring were marked in such a manner as to show clearly on both the photographs and the cephalometric x-ray films. The facial photographs were taken one-quarter size with a National Gnathostatic Camera. The mouth photographs were taken three-quarter size and the lateral views were oriented to have the top of the negative parallel with the eye-ear plane. Thus, the relationship of the labial surfaces of the teeth may be readily correlated with the facial photographs. The cephalometric x-rays were taken with a Broadbent Bolton Cephalometer. As the facial outline, the teeth, and the orienting landmarks may be seen on the negative, tracings taken from these negatives are of great value in checking the photographic data. The primary objective of the study was to determine whether or not the arrangement of anterior teeth might follow definite patterns peculiar to the various facial types, in those cases where a fine harmony existed between the facial types and the tooth arrangement. The 105 selected cases were segregated according to the Simon classification and the following distribution was noted as shown in Fig. 3.

DISTRIBUTION OF FACIAL TYPES IN 105 CASES

TYPE	NO. OF CASES
Maxillary protractions	18
Maxillary protractions with mandibular retraction	69
Bimaxillary protractions	14
Bimaxillary retractions	1
Mandibular retractions	3
Mandibular protractions	0

Fig. 3.

A study of the photographs and tracings and cephalometric radiographs revealed the following data:

Maxillary Protraction (Figs. 4 and 5).—The facial profile is in general convex. The convexity is dependent upon the degree of protraction; the summit of the convexity is in the middle third of the face. The occlusal plane deviates from the eye-ear plane by approximately 15 degrees. The labial surface of the central incisor is curved incisal-gingivally, being in harmony with the convexity of the face. The angle between the labial surface of the incisors and the occlusal plane is greater than 90 degrees. The gingival portion of the central incisor is more prominent labially than is the incisal portion. The central lateral and cuspid follow a similar pattern having the gingival more prominent than the incisal edges. The lower incisors have their long axes approximately at right angles to the base of the mandible. This tendency has been previously noted by other investigators.[9] Little or no overjet exists.

Mandibular Protraction.—(No complete records available for study to date.)

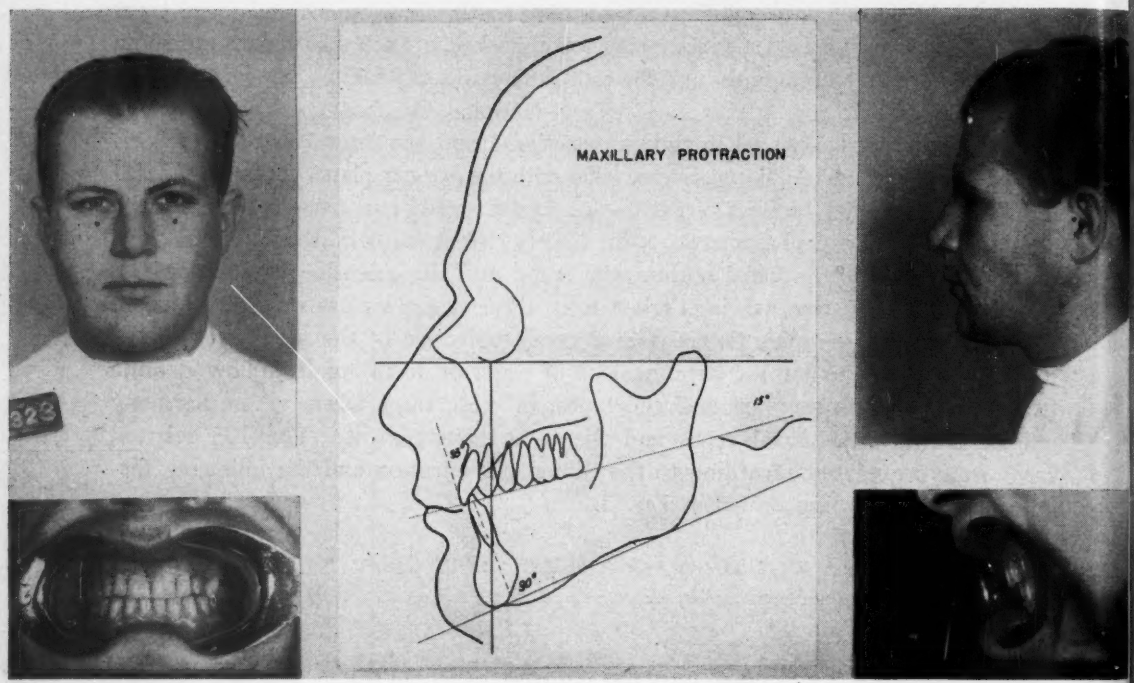

Fig. 4.

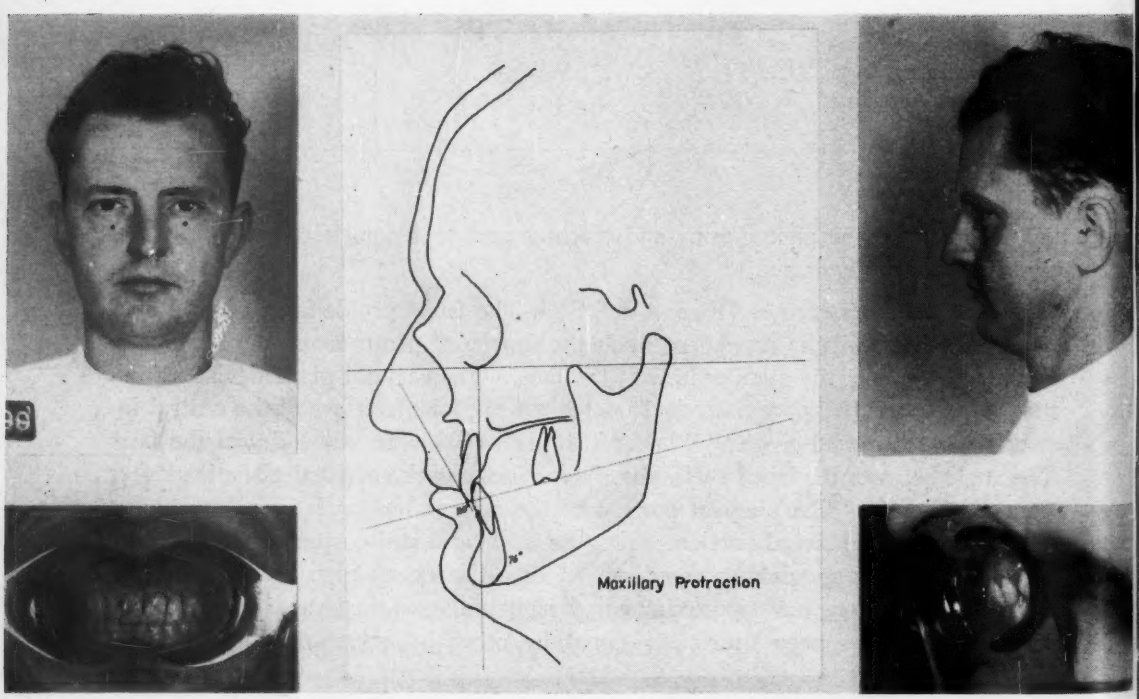

Fig. 5

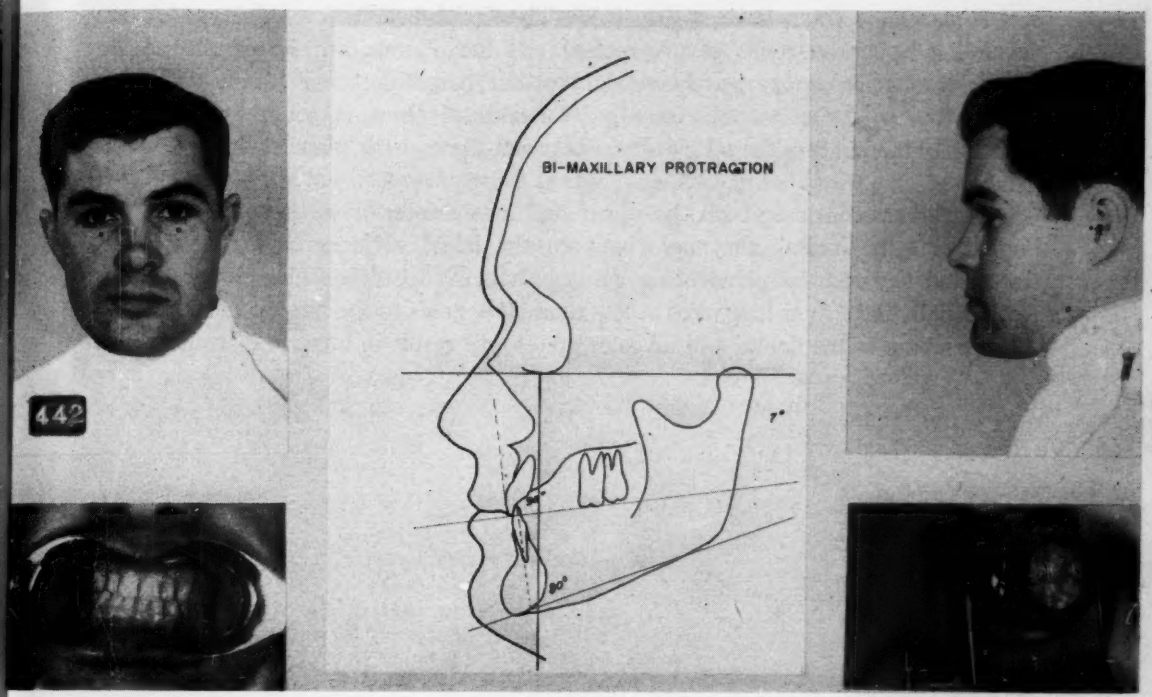

Fig. 6.

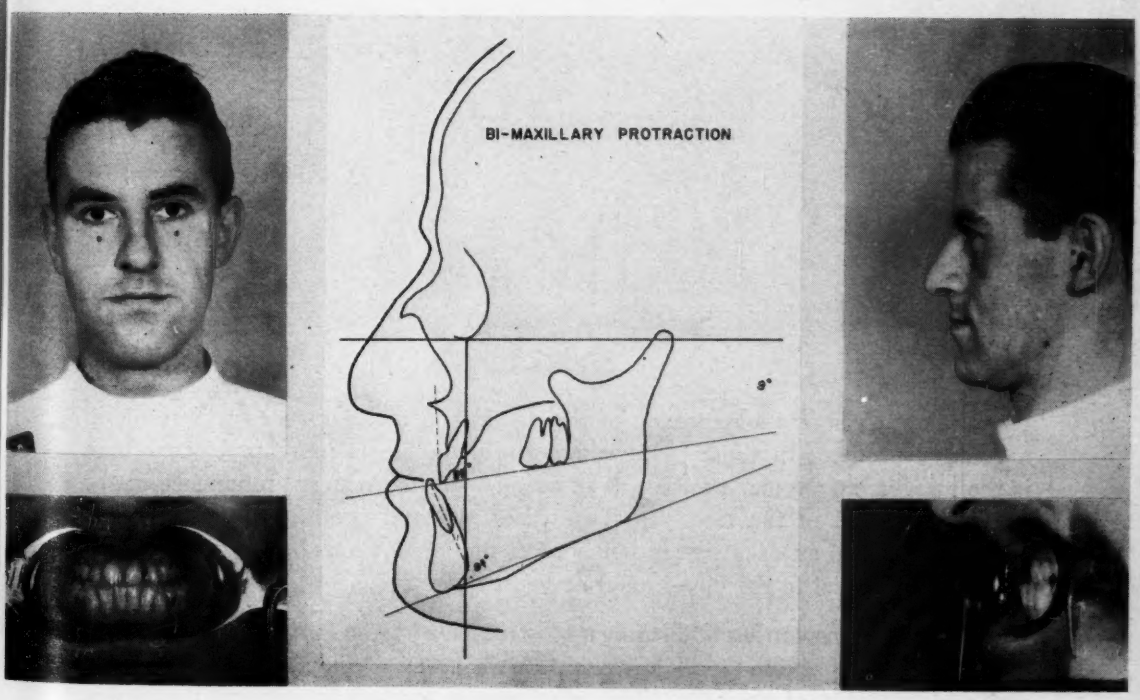

Fig. 7.

Bimaxillary Protraction (Fig. 6.).—The facial profile for this type varies, depending upon the zones of protraction. If the dental and alveolar zones are not protractive, a comparatively straight profile, slightly prominent in the lower two-thirds, will be commonly found. The occlusal plane is generally depressed posteriorly having less than 15 degrees between the eye-ear plane and the occlusal plane.

In this type of case both the upper and lower anterior teeth will be inclined lingually at the incisal, the angle between the labial surfaces of the central incisors and the occlusal plane being greater than 90 degrees. The lower anterior teeth usually have their long axes at less than 90 degrees to the base of the mandible. A protraction of the dental and alveolar zones will result in a convex profile of the

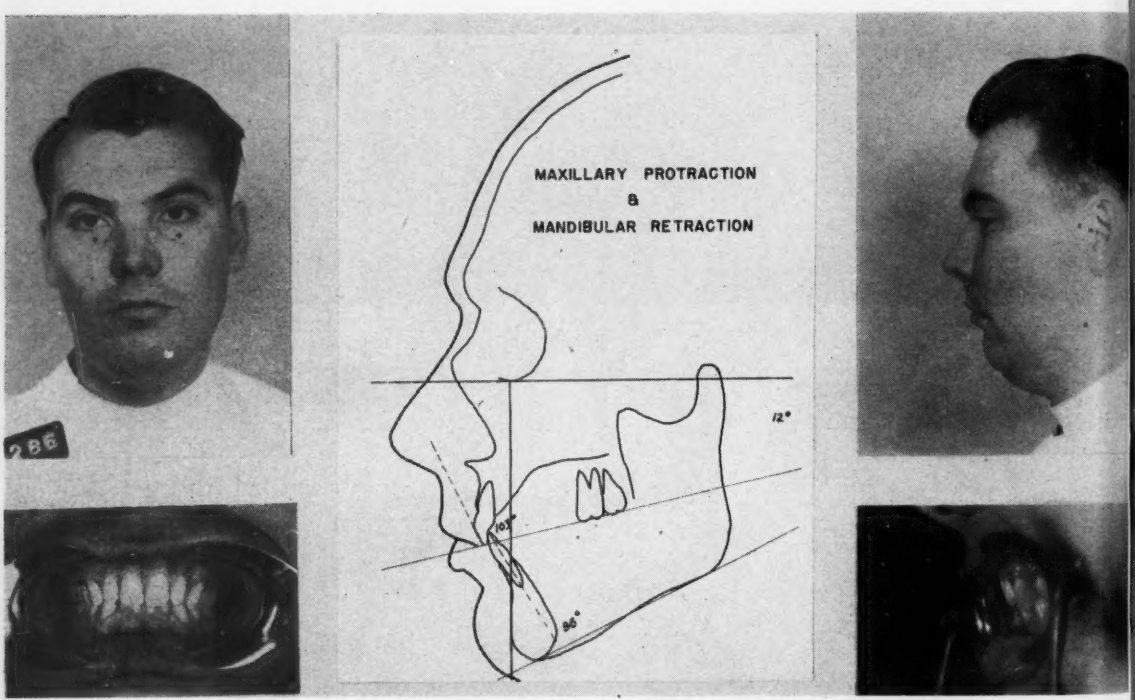

Fig. 8.

Negroid type whereas a retraction of the dental and alveolar zones will result in a concave profile. In those cases where the mandible is more protracted than is the maxilla, an angular profile will be found with its greatest prominence in the mandibular third of the face. In these cases a dental protraction frequently is noted resulting in an excessive prominence of the lower lip and the lower anterior teeth may be labial to the upper anterior teeth (Fig. 7).

Maxillary Protraction in Conjunction With Mandibular Retraction (Fig. 8).—The facial profile of this type is convex with the greatest prominence in the upper and middle thirds of the face. The subnasion is located anterior to the nasion and the gnathion posterior to the orbital plane. The upper anterior teeth in this

type of patient are prominently curved incisal-gingivally and are so arranged that all the anterior teeth incline lingually at the incisal. In this respect the upper teeth follow the same arrangement as in the case of maxillary protraction. It should be noted that there is frequently a tendency for the upper lateral incisors to lap the upper central incisors, the centrals being more lingually inclined at the incisal than the laterals. The lower anterior teeth in this type of face frequently incline labially, thus reducing the overjet which might normally be expected due to the distal location of the gnathion. The inclination of the lower central incisors with regard to the base of the mandible is frequently greater than 90 degrees, the lower anteriors leaning anteriorly.

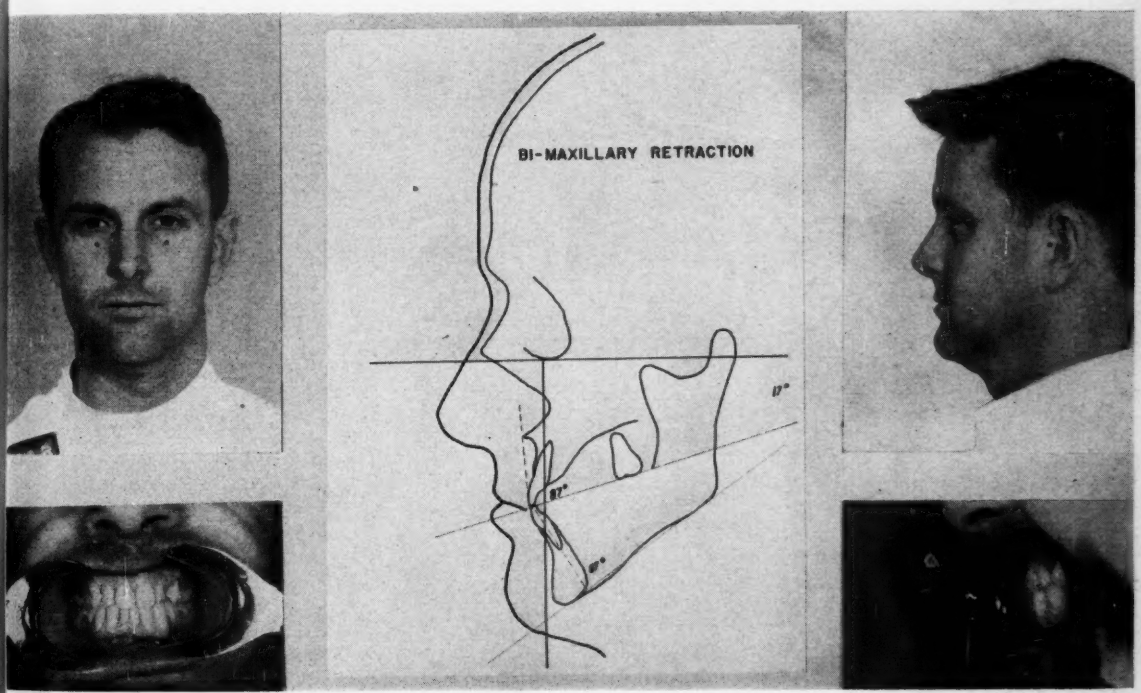

Fig. 9.

Bimaxillary Retraction (Fig. 9).—The facial profile of this type varies from concave to straight depending upon the zone and the amount of retraction. If an alveolar retraction exists the profile will be found to be slightly concave. This type is usually characterized by deep nasolabial sulci. The upper and lower central incisors meet each other with an edge-to-edge relation. The upper anterior teeth are inclined labially at the incisal as are the lower teeth. The long axes of the lower teeth are nearly at right angles to the base of the mandible. When a straight profile is encountered, the upper and lower anterior teeth may be found to have a perpendicular relationship to the occlusal plane and to have more overjet than overbite. Insufficient cases of bimaxillary retractions have been studied, to date, to render reliable information.

Mandibular Retraction (Fig. 10).—The facial profile of this type is convex, the convexity being much more prominent in the upper two-thirds than in the lower or mandibular third. The occlusal plane is elevated posteriorly, having greater than 15 degrees of angulation between the occlusal plane and the eye-ear plane. The upper anterior teeth are more prominent incisally than gingivally. The angle between the labial surface and the occlusal plane is less than 90 degrees. The lower anterior teeth seem to incline labially, but are frequently at right angles to the body of the mandible. In cases of this type where the retractive tendency of the mandible is more pronounced, the overjet increases and the lower anterior teeth are inclined more anteriorly.

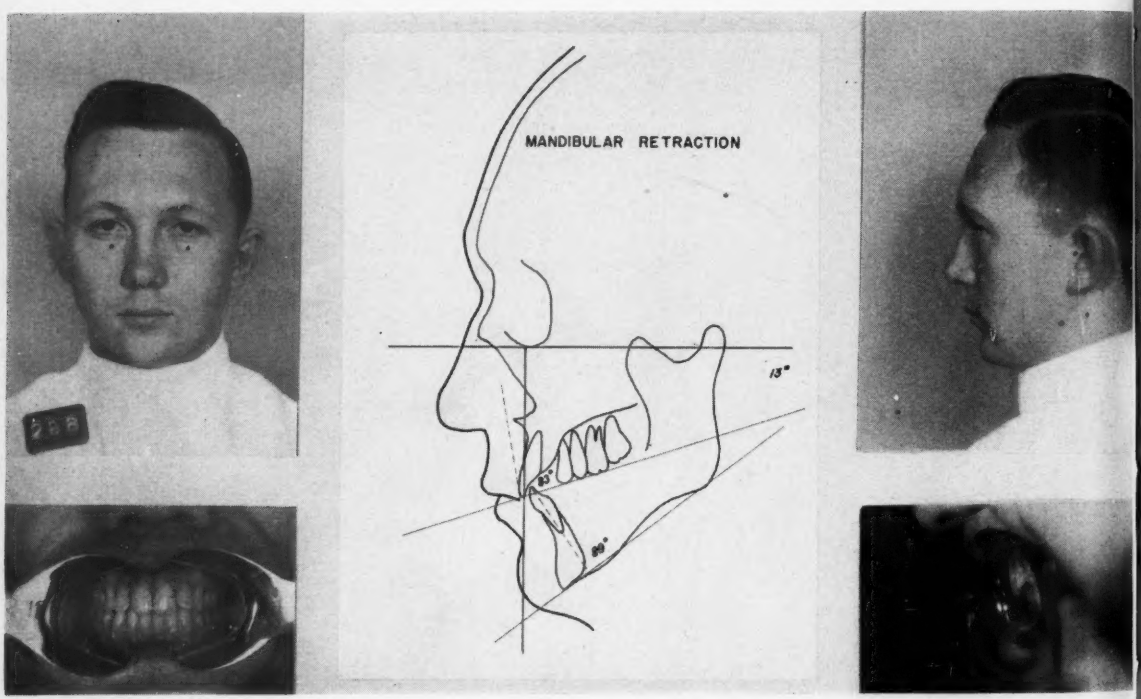

Fig. 10.

Attraction (Fig. 11).—As this type is a vertical deviation from the norm, care must be taken to have the patient in centric occlusion before classification is attempted. It is believed that an excessive free-way space is typical to this type. The excessive free-way space in the rest position tends to obscure the condition. When the teeth are in occlusion, the profile of this type of patient is characterized by the deep mental sulcus which is not nearly as prominent when viewed in the rest position. The profile will vary in accordance with protractive or retractive tendencies of the individual case, as will the tooth arrangement. The most important factor peculiar to this type will be the difficulty in establishing correct vertical dimension in edentulous cases due to the need for greater than average free-way space.

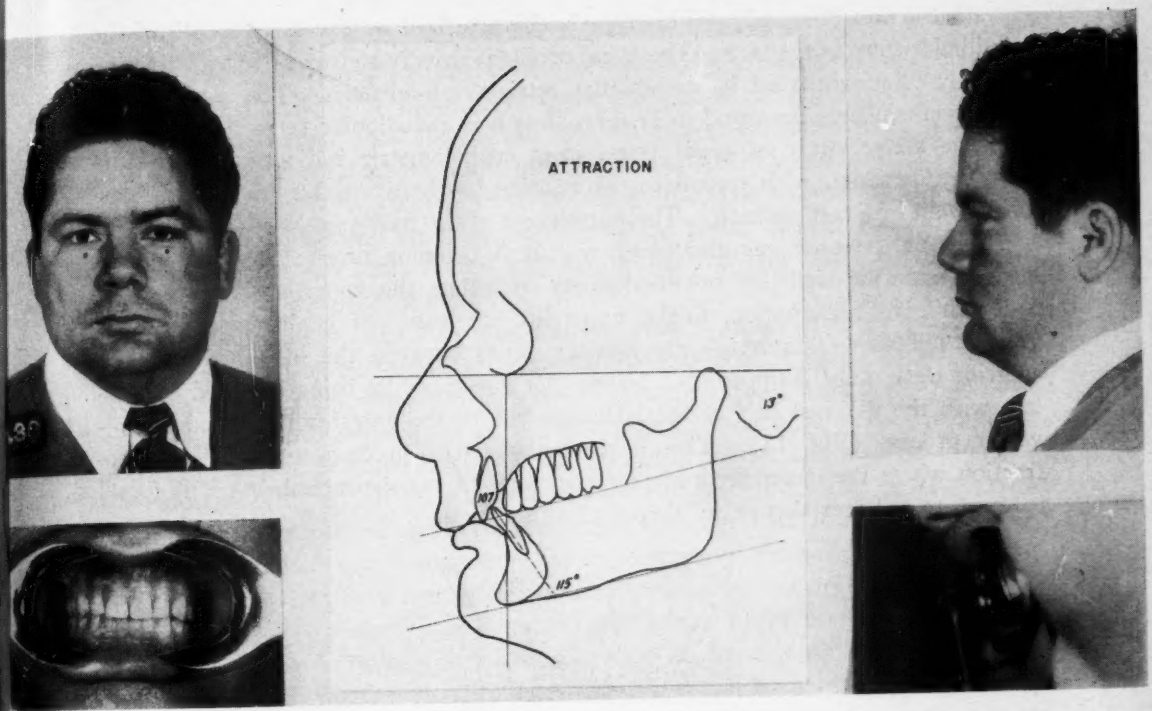

Fig. 11.

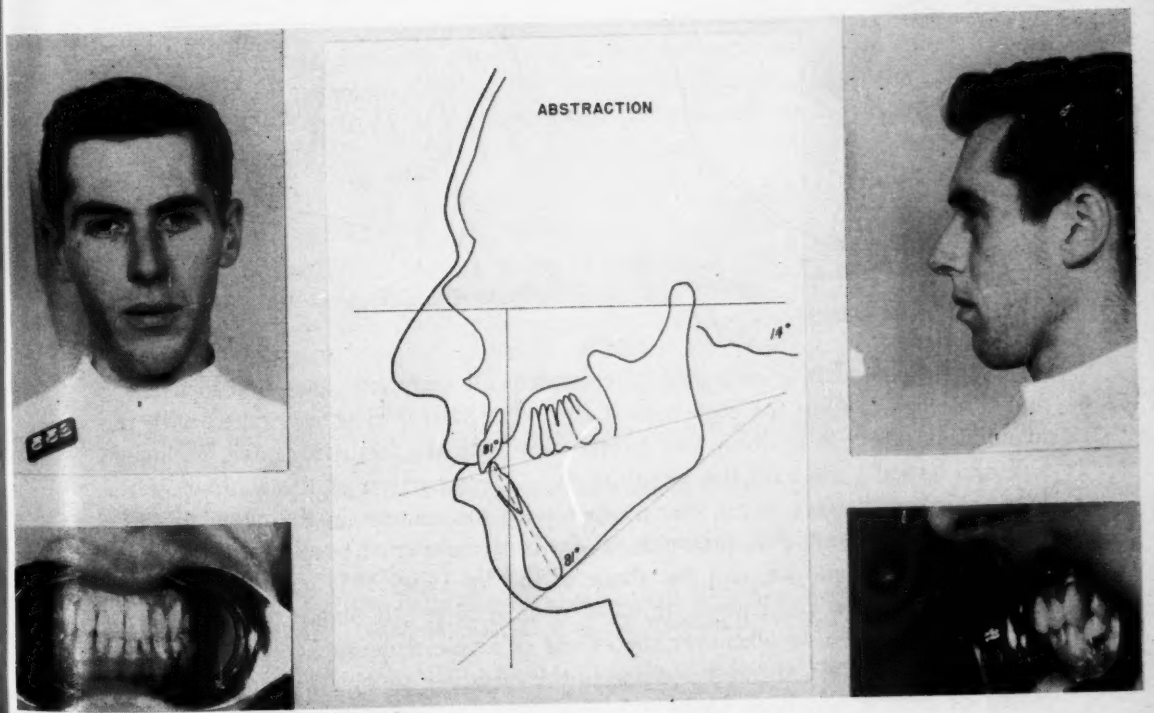

Fig. 12.

Abstraction (Fig. 12).—This type is characterized by excessive length of the mandibular third of the face. The facial profile is usually convex as this abstraction generally is accompanied by mandibular retractive tendencies. The arrangement of the teeth follows the usual inclinations found in mandibular retractions.

The above study of facial types from cephalometric radiographs also furnished information with regard to the relationship between the lips and the anterior teeth in a rest position. The importance of the free-way space in an evaluation of facial contour was also observed. It is common practice in the arrangement of anterior teeth for prosthodontists to incline the upper anterior teeth in order to give full support to the upper lip. A study of cephalometric radiographs will show that frequently a space exists between the incisal half of the anterior teeth and the upper lip. Support of the upper lip being supplied by contact with the gingival half of the labial surface of the anterior teeth and the alveolar process (Fig. 13). This is particularly true in cases of maxillary protraction where the upper teeth are inclined lingually at the incisal, but it is found to exist to a lesser degree in almost all other types.

Fig. 13.

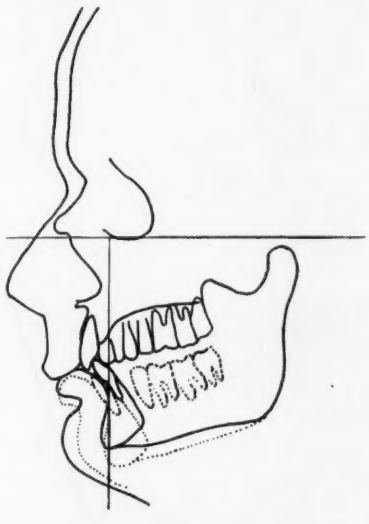

Fig. 14.

The cephalometric radiographs consisted of four sets, one anteroposterior and three lateral films for each case study. One lateral view was taken with the mandible in the rest position, one lateral view with the teeth in centric occlusion, and one lateral view with the mouth open. A comparison of the contour of the lower third of the face in the rest position with the contour in the closed position will reveal considerable deviation in the form of the mental process, the elevation of the labial commissure, and the shape of the lip (Fig. 14). This modification of contour is noted particularly in cases of attraction. It should be a matter of interest, therefore, that whenever the effects of artificial dentures upon facial contours is being studied, the rest position of the mandible should be used and not the closed or centric occlusion position.

SUMMARY

To summarize the above data, it may be said that if protractive tendencies exist in either the maxillary or mandibular areas, the gingival of the anterior teeth become more prominent than the incisal. As retractive tendencies exist the incisal of the anterior teeth become more prominent than the gingival. Lips are supported primarily by the gingival third or half of the centrals and laterals and not by the incisal portion of the labial surface of the teeth. Facial contours should be studied in the rest position and with the proper free-way space present if natural appearance is to be observed.

The information from this study is of primary value in those cases where adequate pre-extraction records are not available; however, the data presented may also be found of value when modification of existing natural conditions is required in order to improve esthetic values. If edentulous patients are studied and classified in accordance with the Simon classification, the above data may be applied in the majority of cases. If this is done, the anterior teeth thus may be arranged in harmony with individual facial types and the esthetic value of artificial dentures will enhance rather than detract from the appearance of the patient wearing them.

The above data have been presented as a preliminary report as only 105 cases were studied. It is hoped that the study will be continued until sufficient typical cases are available to make a complete analysis of all possible combinations of facial types. It is recognized that individual arrangement of human teeth is infinite in number, but it was hoped that some semblance of uniformity might be ascertained for the typical arrangement in accordance with facial types. It is felt that there is sufficient evidence to indicate typical harmonious arrangement of teeth for the major facial types as has been shown. Further investigation may call for a classification of faces more suitable than the Simon classification. However, until such investigation is completed, it is believed that the material presented herewith shall be of considerable value to students, teachers, and practitioners in the field of denture prosthesis.

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THE MEDICAL CENTER
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TOOTH FORM AND FACE FORM, IS IT A "COMEDY OF ERRORS"?

JAMES W. CARSON, D.D.S.

Los Angeles, Calif.

IN a recent issue of one of our magazines, an article[1] was published under the title, "Tooth Form and Face Form — A Comedy of Errors."

May I recall to your memory, very briefly, some of the contributions of certain men supporting the principle of harmony between tooth form and face form.

It was not my good fortune to have known Dr. J. Leon Williams* personally, but I have read about his background and early life, as well as his professional attainments and contributions to the science of dentistry. Incidentally, an interesting and informative reflection upon Dr. Williams' character, professional standing, and attainments (and this goes for any man) may be found in knowing his friends, associates, and interests. Among the better known of his friends and associates, in the early days of a struggling profession, were such men as W. D. Miller, G. V. Black, E. C. Kirk, R. Ottolengui, Alfred Gysi, C. N. Johnson, George H. Wilson, and as time went on, many others including our own Milus M. House. Dr. Williams' interests were in debunking the philosophic theories about growth and development, not by ridicule, but by scientific evidence. He also had a great appreciation of harmony in nature as evidenced by his many paintings.

Dr. Williams did much in promoting the study of harmony between tooth form and face form. He called attention not only to the pure types but also to many variations. There are two general types of variations: First, those caused by genetic mixtures or the genetic variability. The mating of a man of one general type with a woman of another general type. This could stand much discussion and study, but for this paper the calling attention to it will have to suffice. Second, those caused by nutritional deficiencies. Dr. Williams had to leave the cause of many of those variations to the late Dr. Weston A. Price, who showed the influence of malnutrition on the development of the face. Dr. Price has called particular attention to the effect of processed, refined, and devitalized foodstuffs, deficient in minerals and vitamins, upon the middle third of the face. It produces a narrowing of the dental arch with its accompanying constriction of the air passages. The lower third of the face may be variously affected. This obviously produces a conflict in nature's plan, since the pattern for the tooth form has been laid down and is beyond the influences of nutritional deficiencies. The further we go along our present trends in abandon-

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*Doctor of Dental Surgery; Fellow of the Royal College of Surgeons of Ireland; Fellow of the Royal Anthropological Institute of Great Britain and Ireland; Fellow of the New York Academy of Science; Fellow of the American Academy of Dental Science; Fellow of the American College of Dentists.

ing whole foods for the packaged, dehydrated, and devitalized products of the commercial interests who care for naught but their own financial gains, the more variations, disharmonies, and catastrophies we will see, not only in facial development, but also in general physical degeneration.

In these cases are we to leave the tooth selection of our denture patients to the commercial laboratory and the tooth manufacturers? "The patients have wrecked themselves, we can do no worse."

I am sure the letters "F.R.A.S." after Dr. Williams' name do not mean "Fellow Royal Academy of Swindlers," as suggested by the afore-mentioned article. The men with whom Dr. Williams associated and labored were not those who fraternized with swindlers. The man who has contributed more than perhaps any other contemporary investigator in this field is our own beloved Milus M. House. Those of us who have been privileged to study and work with him and to see the many specimens skulls and extracted teeth he has from all over the world can appreciate this fact. To see the evaluation he makes of what he finds in nature, both in the normal, or uninterrupted, and in the abnormal, or disturbed cases, in contrast to some of the pet theories which other men try to substantiate, is one of the most reassuring experiences one can have in the search for truth.

Dr. House has followed, checked, and verified the works of Dr. Williams in regard to both tooth and face harmony, and he has added to the store of scientific proof of their reliability. The fact that we have so many malformed faces to attempt to restore to a semblance of normalcy is no license to abandon what scientific information we have at our disposal in seeking the answer. Rather, we should enlist the advice and experience of those men whose background is rooted in fundamental biologic science. Men who have learned to observe what they see. Men who chronicle what they observe, letting the chips fall where they may. In these days of isms, including commercialism, it is unfortunate that an attack should be made by a professional man upon one of the most fundamental principles of esthetics. Strangely enough, a tooth manufacturing company is following the lead of the good doctor and trying to capitalize upon it. I wonder what the connection is.

I say that it is unfortunate at this time that this attack should be made, or is it? If it serves to stimulate the younger men to seek the truth for themselves, following the paths marked unmistakably by signposts of the truth of cause and effect, growth and development, and a sense of the highest in professional attainment, then, perhaps, it will have served a good purpose. We must remember always that our first and greatest obligation is to the health and comfort of our patient. We must not sell our birthright for a mess of pottage.

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ESTHETIC DENTURES AND THEIR PHONETIC VALUES

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THE purpose of this paper is to present a method of treating the problem of phonetics based upon the belief that nature knows best. Natural esthetics plays the dominant role but it is not the subject of choice; it is purely a subject of necessity. It is a subject of necessity because of the tremendous influence it exerts upon the primary subject, phonetics. Phonetics on the other hand is a subject that has long been neglected in dentistry. It is one upon which little has been written and less known. It is a subtle subject, the study of which we have hardly known how to approach, and this paper will give a new approach and a new solution to this evasive phonetic problem.

This new approach is based upon the fact that it has been my observation and it is my opinion that phonetics is controlled 100 per cent by esthetics. While studying and endeavoring to perfect phonetics it has been impossible for me to separate these two. In fact, I have found it necessary to study esthetics in much greater detail than ever before in order to help solve this problem of phonetics. But, in referring to esthetics, I do not mean the esthetics which are usually terminated by setting the correct teeth in their correct position in the arch. I mean the esthetics which are not terminated until the supporting structures of these teeth, that is, the denture base material, are accurately reproduced to the correct form of the interdental papillae. It is true that if the teeth are not naturally positioned, one should not expect normal speech. But, even if the teeth are correctly placed, unless the true anatomy of the investing tissues which was lost incidental to the loss of the teeth is restored, clarity of voice and diction is impossible in dentures.

For a moment, let us consider ourselves a specialized group of architectural engineers, who are specializing in rebuilding the structures and acoustics of the oral cavity, engineers to whom I have the pleasure of pointing out that the natural architecture of the dental arches is the basis of acoustic and phonetic perfection.

These structures, these dental arches, were designed and built by nature, which we might well call the master architect. They were designed for the purpose of giving us three of the blessings of life: (1) the tools of mastication; (2) the benefits of an esthetic laugh and smile; and (3) the advantages in the refinements of singing and speaking.

We, as architectural engineers, specializing in the rebuilding of these oral structures after they have been destroyed by the inroads of age, infection, and

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extraction, must be prepared to restore not one or two but all three of these blessings. The simplest way we can accomplish this is for us to copy the natural basic architectural design as it has been given to us by nature. If we do this, we shall then be automatically reproducing in true position and form all the intricacies of these natural structures, not just the teeth alone, but also the balance of the architectural anatomy that has wasted away.

By this method, in addition to replacing the teeth, we shall be restoring the beautiful contours of the gingival and other tissues which are such an asset to an esthetic smile. Also, we shall be replacing in that mouth, which I call the oral voice box, in its true relation to the other oral structures, the same bulk of material which it contained originally. In this way we are assuring our patient of normal voice and diction. Finally, after all this, if we tint and color the denture base material to more closely simulate living tissues, we shall then, and only then, have fulfilled the hope and confidence placed in us by our denture patients.

And while on the subject of tinting artificial gums, do you realize the American people spend millions of dollars each year to tint their fingernails—not to mention toenails. They spend many more millions tinting their hair the right—and the wrong—color. And possibly the amount of money spent tinting complexions each year is comparable to a presidential budget. What do you think these same people would spend to have their artificial gums tinted to look like the real thing? The answer is self-evident, and yet this phase of prosthetic dentistry has been in the doldrums for years. The natural fashioning and tinting of our denture base material is almost a lost art, originally attempted only by those who made continuous gum dentures. Why is this? Any color, tint, or shade can be developed in acrylic, and yet, since the introduction of the methyl methacrylate denture base material, we have relaxed and said, "This is it. Here is a material that really looks like the natural gums." Possibly we are not to be blamed since it was such a vast improvement over vulcanite and Resovin, yet the truth remains that we have made no attempt to put natural colors and character into our artificial gums. We have been asleep to the fact that we could and should be rendering our public a much finer esthetic service, and asleep to the fact that dentistry could be acquiring some of these millions that are being spent for tinting.

ESTHETIC PRINCIPLES IN NATURE

It is this belief in the error of our ways which has led me to practice and design dentures according to the principles of nature and not according to the principles of dentistry. I have found when this is done that dentures have an entirely new appearance and a naturalness of speech which is surprising. For this reason I often refer to them as "Dentures with a New Look—that speak—by themselves." In developing this "New Look" in dentures there are three phases to be considered:

1. Natural setting of teeth.
2. Development of an entirely new concept of denture form.
3. Reproduction of the natural colors of living tissues.

The natural setting of teeth involves many problems which, as we all know, are based on an understanding of sound fundamental principles and of studying patient individuality. However, there are four such principles which are neither taught nor recognized in dentistry today, and these we must observe if we expect to develop esthetic dentures that will speak by themselves. I have found all too frequently these principles are not incorporated in the setups on our modern dentures, and here is where the first of our subtle problems of phonetics enters the picture.

The first of these principles has a definite bearing upon esthetics and upon tooth-to-tongue relationship. It is that the natural plane of occlusion is parallel to the floor when the patient is standing or sitting in a normally relaxed position. One can easily recognize this fact by simply observing people. Many individuals, during conversation, show their teeth as far back as the first molar. It takes a careful observer but a short time to realize the accuracy of this statement. When the bite blocks are almost completed, it is well to have the patient stand and walk about, possibly observing something at eye level, and when apparently relaxed, ask him to hold steady, open his mouth slightly, and close on the thin blade of a cement spatula. Observe if the spatula handle is parallel to the floor; if it is tilted up or down, the bite blocks should be adjusted to bring it to a level plane. This procedure assures a normal display of teeth on either side of the mouth and places their occlusal surfaces, for the length of the denture, in correct relationship to the tongue.

The second principle is the development of the correct clearance between the anterior teeth. It has been found most advisable for the operator to first set up roughly the twelve anterior teeth and then contour the remaining bite blocks to allow adequate tongue space. At this point the first try-in should be made, and the final selection and setting of these twelve teeth is completed right at the chair. After these teeth are set, there should not be more or less than 1 or 2 mm. clearance between the incisal edges of the anterior teeth when the patient is unconsciously repeating the letter "S." This can easily be ascertained in the following manner: Have the patient count several times from 1 to 10. This count should then be speeded up, assuring the patient that speed is the only item of interest, until he is counting as rapidly as possible. When the patient really counts these numerals fast, as he hits the 6 and 7 in rapid succession, the lips automatically fly open and the true clearance can be observed. The teeth should then be adjusted so they are within the limits of 1 to 2 mm. clearance in this function. The only cases in which this clearance cannot be developed are those presenting retruded mandibles. In such cases the same procedure can be followed except the principal point to observe is that there should be only 1 mm. of clearance in the area of the cuspid and first bicuspid.

The third point of importance is to develop the correct amount of tongue room in the posterior part of the dentures. After the anterior teeth are finally set, draw a line on the lower bite block from the mesial of the lower cuspid back to the most lingual aspect of the retromolar pad area; another line is then drawn from this same point to the most buccal aspect of the retromolar pad area. The important thing is to keep the lingual surfaces of the lower molars within the confines of these two lines. (Fig. 1.)

Usually the position of the lower posterior teeth is controlled by the setting of the upper teeth. Normally the correct setting of the upper teeth will throw the lower lingual surfaces between these two lines but, if this does not occur, the setting of the upper teeth should be adjusted so the lowers will fall within these limits. If it seems necessary to set the upper teeth too far off the upper ridge in order to accomplish this setting, then the lower teeth should be set up to a crossed bite, thus permitting a more normal setting of the uppers, and thereby keeping the lowers in a position of normalcy in their relation to the tongue and the retromolar pad. This principle can be easily established in our dentures and is one that has much to do with denture stabilization and natural tongue action.

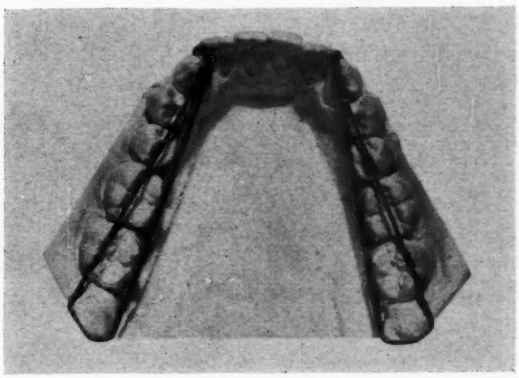

Fig. 1. — Study model showing the lingual surfaces of the posterior teeth and their relationship to the retromolar pad area, and the mesial of the lower cuspid.

The fourth principle in the natural setting of teeth deals with the relationship of tooth to ridge. It is common practice in dentistry today to set teeth directly over the center of the ridge. I believe this principle precludes the development of either esthetic or phonetic dentures simply because teeth did not originate from this position. It is common knowledge that postextraction tissue loss is greater on the buccal and labial aspects of the ridges than on the lingual. This creates a ridge center which is definitely more lingual than was the center of the teeth prior to extraction. This fact can easily be demonstrated by making cross sections of models through edentulous areas and comparing ridge centers with the position of the remaining teeth. (Figs. 2 and 3.)

Because of these observations and proceeding on the principle that teeth should be replaced in the exact areas from which they came, I seldom find it advisable to place any teeth over the ridge. They should be set in an anterior, buccal, and occlusal position, and it should never be necessary to grind properly selected teeth because of ridge interference.

Two reasons for the practice of setting teeth over the ridge are based upon theories of leverage and ridge absorption. The theory of leverage is questionable at the outset, but it is my belief that leverages, or the tilting of dentures, is more easily controlled by the balanced setting of teeth than by the positioning of teeth. In this respect one might follow the doctrine of Dr. T. V. Boswell of Springfield,

Mo., who has been wearing full dentures for years. He sets teeth buccal to the ridge and makes the buccal slope of the buccal cusps of the lower molars the active inclined plane, in place of the lingual slope, thereby assuring a downward and inward drive on the lower denture during mastication.

The theory that ridge absorption is increased by setting teeth off the ridge may have merit; however, my personal experience does not substantiate this theory. Edentulous patients with a history of absorption or pyorrhea are treated as systemically undernourished individuals, and are routinely given medical physical examinations and nutritional advice. It is seldom necessary to refit healed cases. To consider sacrificing known esthetic and phonetic advantages, in favor of questionable results obtained by setting teeth over the ridge, would not be in accordance with patient histories.

Fig. 2.

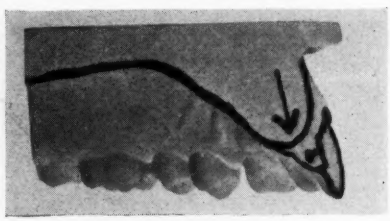

Fig. 3.

Fig. 2. — Cross section through upper first molar area showing the normal tooth position on one side and the lingual position of the center of the ridge on the other.

Fig. 3. — Cross section through the upper central incisor. Black lines indicate correct position of pin tooth in relation to a postextraction ridge. Arrow indicates lingual position of center of ridge.

In the discussion of the natural setting of teeth the fact should be mentioned that there are, of course, those exceptional cases of individuals whose appearance and even speech can be improved by setting teeth differently from their normal dentition. Another point to consider is the fact that patients who are pleased with the esthetics and phonetics of their dentures seldom develop denture problems annoying to the dentist or themselves.

FASHIONING THE DENTURE BASE MATERIAL

The second phase of this subject, that is, the fashioning of the denture base material, is one which should be given detailed study. This is a neglected phase of dentistry, and our apathy toward this subject has created many of our phonetic problems. Words are completely inadequate to describe the differences that exist today between the form of our dentures and the form of those portions of the mouth they are supposed to reproduce. One reason we have not been conscious of this difference is that we have not compared them side by side. It behooves every one of us to procure study models of normally shaped mouths, some of the best dentures we can find, and then study and compare them. Using a magnifying glass, study in detail the form of the gingival tissues on all sides of the natural teeth, and then notice the unnatural way a denture is made. Study the shape and fullness of the bone and gum structures supporting these teeth, and then observe the dentures and notice how inadequately these structures are re-

stored. Notice how we have been grooving our dentures and attempting to identify root prominences that do not exist. (Fig. 4.)

Also notice how crudely our dentures have simulated the natural palatal areas both with regard to the gross anatomy and the contours of the individual tissues. The ability we develop to accurately reproduce nature in our denture bases will control to a great extent the phonetic qualities we give our dentures.

Fashioning the palate areas is most important from the phonetic standpoint, and this study can be divided into three phases:

1. Contouring the lingual aspects of the porcelain teeth.
2. Duplication of any undistorted part of the palate of which there is a record.
3. Uniting these two areas in true anatomical form.

Fig. 4. — Denture showing natural gum contours on one side in contrast to the unnatural contours we have been using on the other side.

Properly contouring the lingual aspects of the anterior and posterior artificial teeth is seldom ever attempted in most dentures. Usually in waxing up cases, the palate form is started where the lingual porcelain ends. This is incorrect because it does not give the artificial teeth their full lingual length. This natural length should be developed in the wax and each tooth individualized, then the palate material develops with character from this point. A study of these two methods will show that in the latter there is much less bulk of material directly lingual to the teeth and this is a very important factor in pronouncing consonants. Improperly developed tongue space is the cause of many phonetic errors. This simple fundamental in developing tooth form has not been observed because we have not recognized this error as one of phonetic importance, and because we have been permitting inadequately trained technicians to do this work. The introduction of pinless and plastic anterior teeth has helped somewhat in the more natural fashioning of palatal areas. However, it should not be assumed that these lingual contours are always correct because many of them do not have a fully developed lingual surface and must be re-contoured in wax. If we do not care to carve our own dentures, we should at least respect the confidence our patients have placed in us and respect our dentistry sufficiently to at least see that this carving is done properly.

The second phase of palate reproduction is one that has to do with those portions of the palate which we are able to faithfully copy in every detail. The phonetic quality of dentures and their comfort to patients are in direct ratio to the amount of the oral voice box that we are able to copy exactly. This brings to attention another neglected phase of dentistry and another service that should be rendered more frequently than it is. It is the story of study models. One of the first services that should be rendered every new adult patient is to make

for that patient a permanent, and very accurate stone record of whatever teeth and investing tissues he may still possess, and to inform him that these models should be preserved as a permanent record. They may become of inestimable value to him in case of accident or the natural loss of teeth. Before making dentures, inquiry should be made of the patient as to the possibility of his having such models. Should he have, these may be used in copying palatal areas to much better advantage that just copying that small area of the palate which has maintained its true form during the years of periodic tooth loss and bone absorption. It is possible to visualize the reproduction of an entire palate from an old study model in which all the teeth are present, and the adaptation of it to a full denture for this same patient. Surely if his denture is contoured as his own palate was when the natural teeth were in place, it is going to function and feel better than one fashioned from memory.

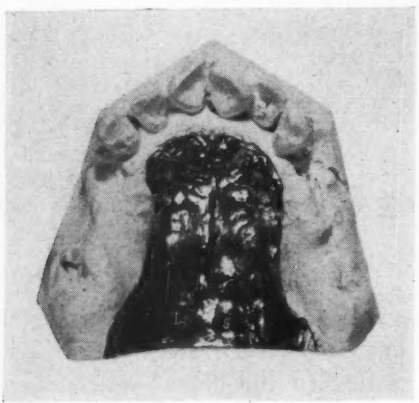

Fig. 5.

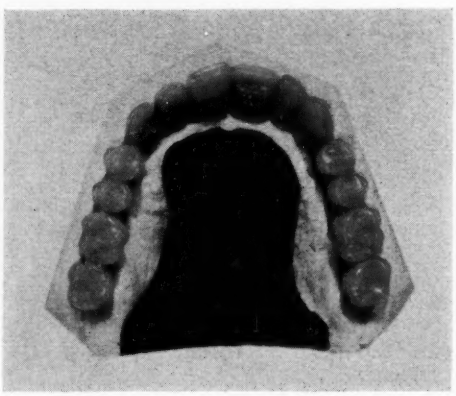

Fig. 6.

Fig. 5. — Tin foil adapted to the area of the palate that remains normal.

Fig. 6. — This model shows: (1) the extent to which palatal baseplate has been removed, (2) the lingual carvings around the procelain teeth, and (3) the adaptation of the palatal wax.

In reproducing palates, it is most important to recognize how much or how little of the natural palate still remains. This should be outlined on the cast or on a former study model, if we are fortunate enough to have one. Then the following technique can be applied in order to develop the same details on the tongue side of the denture as exist or previously existed on the palate itself:

1. Outline on the cast the still normal areas to be reproduced.

2. Trim and carefully adapt with sponge rubber a piece of 0.003 tin foil to this outline. (Fig. 5.)

3. Remove the foil and set it aside for future use. (This step should be completed before the setup is started.)

4. After the setup is completed, remove the entire palatal baseplate.

5. Contour the lingual surfaces of all the teeth true to form. (Fig. 6.)

6. Carefully adapt one thickness of Kerr's red strip boxing wax to the outlined area without folds (by cutting). This wax will work without stretching at finger temperature and will assume the convolutions of the rugae, etc., quite easily.

7. The previously fashioned tin-foil control is now to be adapted to this wax. The wax, by virtue of its thickness, has created a dimensional change in the palate so that the tin foil is now slightly oversize. Carefully center the foil and start matching it to the irregularities of the wax. As it is worked into place, because of its resiliency, it will collapse sufficiently to assume the new dimensional changes without losing its basic convolutions and the detail previously swedged into it. (Fig. 7.)

8. This foil remains in this position during the flasking operation, but is of course eliminated when the wax is boiled out of the case.

Two phases of the esthetic palate contour are now completed: the lingual of the teeth and a portion of the palate itself. The remaining portion must be waxed in next. (Fig. 8.)

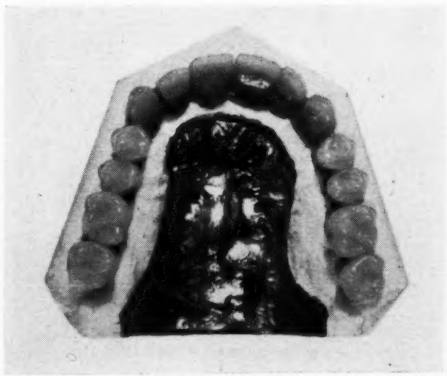

Fig. 7.

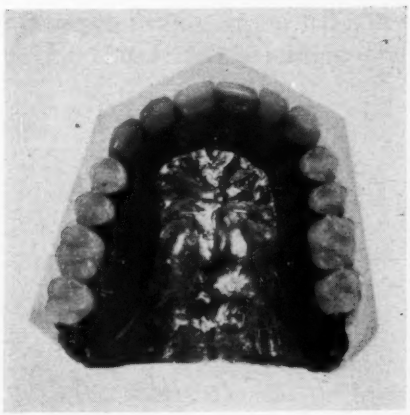

Fig. 8.

Fig. 7. — This shows the additional detail achieved by applying the previously adapted tin foil to the wax.

Fig. 8. — This shows how the balance of the palate should be waxed by hand to simulate natural palatal contours.

It is here that a sound knowledge of tissue anatomy is imperative. Careful study of natural matured palates will develop this knowledge. Words are never adequate. However, there are several outstanding characteristics found in most palates which should be mentioned. For example, in the posterior area, that is, from the mesial of the first molar distally, there is a marked fullness lingual to the molars. It is essential to restore this fullness because the dorsum of the tongue is then able to control more easily the amount of air that escapes through the center of the palate. To demonstrate this, simply count from 6 to 10 and observe the action of the dorsum of the tongue. Notice that it is more or less stationary on the lingual surfaces of the teeth and on this pad of tissue. The tongue elevates only slightly from time to time to control the amount of air it allows to enter the anterior third of the palate. Only the tip of the tongue moves rapidly as it whips the air about in the rugae area. If the lingual anatomy is not fully developed, the tongue is forced to spread itself in order to contact these surfaces, thus permitting too much air to enter the anterior section. This type of error is responsible for much of the whistling that occurs in dentures. The natural anatomy of the anterior portion of the palate is of great importance

in pronouncing consonants. It is only in this area that rugae appear. I term it the playground of the tongue because 90 per cent of the tongue's rapid manipulation in talking is restricted to this area and to a similar area lingual to the lower anterior teeth. These surfaces should be studied carefully to learn the different types of asymetrical rugae distribution and the usually convex contours of the gingival tissues. (Fig. 9.)

The buccal and labial aspects of dentures should next be considered. To realize the necessity for this study, compare the normal mature mouth with a collection of the finest dentures available. Where we ever conceived the contours we have been placing on these surfaces of our dentures is a source of surprise and astonishment to anyone making an honest appraisal of the situation. Such a comparative study will reveal the following points:

1. The interdental papillae on dentures are usually brought to a definite point with a flat or grooved effect above the point. The normal papillae are full-bodied and terminate in a blunt and even rounding tip. See Fig. 10.

Fig. 9. — The average palate. Lines indicate the natural fullness lingual to the molars, the slight depression in bicuspid area, and average rugae position and type.

2. The so-called free margin of the gum at the neck of the artificial teeth has anything but a free appearance. It is carved flat and tight to the tooth neck and then blended directly into the base material. In the mouth this tissue stands out in varying degrees, and it is drawn tightly about the tooth with a definite rolled edge. It simulates the cuticle around a fingernail, having a slight undercut so that it shows no direct attachment. This gum tissue never shows a stippled effect, but stippling is evident directly above this tense tissue and is often manifest in the body of the papillae. Tight or tense tissue and the flexible soft tissues are invariably free of the stippled effect. From an esthetic standpoint, artificial gums carved in this manner have a marked naturalness partially because the saliva adheres in this area more normally, enhancing the blend between the tooth and gingiva and dispersing the colors more harmoniously. See Fig. 10.

3. The area above the gingival tissues on dentures is either depressed, grooved, or carved out to simulate root prominences. It is either highly polished or stippled all over. It seems generally to be contoured so as to eliminate bulk. The normal mouth will show almost the opposite. Only the tapering types will show very much in the way of root prominences. In the posterior area, all cases will have a marked fullness starting above the gingivae. This tissue is

rounding, very firm, there is no stippling, and there are no grooves. Above this bulge there is often a depression composed of flexible tissue that blends itself with the muscle attachments. In the anterior area this fullness is usually not as marked but it does exist and slowly fades away into soft tissues and muscle attachments. See Fig. 10.

Another characteristic worthy of note and study is the consistency existing between types of cases and types of tissue anatomy. The gum contours of ovoid cases, for instance, are very plain. They seem to extend upward and outward in a smooth round fullness extending from one end of the arch to the other, and blending into the muscle attachments with no marked depressions or elevations. The square types are surprisingly similar to the ovoid except that they do exhibit stronger character and more interesting formations. The tapering types vary but in all instances they show stronger anatomic markings. Anterior root prominences are sometimes evident and the gingival tissues are beautifully developed.

Fig. 10. — Denture showing natural anatomy such as interdental papillae, free appearance of gum margin, effect of stippling, and the full buccal contours.

Suffice it to say that from an esthetic standpoint the buccal and labial surfaces of dentures have been definitely inadequate, but from a phonetic standpoint they have been given absolutely no consideration. These surfaces may appear to have nothing to do with phonetics, but when it is realized that the natural surfaces, when reproduced on our dentures, create considerably more bulk, and this bulk, or the lack of it, has a definite influence on voice, then we must give credence to the fact that these areas are a part of our subtle problems of phonetics. Dentistry has not recognized the mouth as an oral voice box and that what we put in it can change its resonant qualities. In the past many of us have experienced difficulty in satisfying the demands of professional singers. I believe there are two basic reasons for this: (1) the artificial teeth were not placed in their natural positions; and (2) we did not restore the bulk of the tissue that had been destroyed in true anatomical position and form. In other words, to fill out naturally and replace the lost structures in the oral cavity is an appreciable factor in controlling the resonance of voice.

Webster defines voice as "Sound uttered by the mouth of living beings forming the basis of articulate speech." Hence, if the real basis of phonetic articulation is the voice, the better the voice, the better the articulation. Haven't we been putting the cart before the horse? In working on articulation and enunciation we have thought only of the teeth and the palatal surfaces of our dentures. Shouldn't we also consider the size and shape of dentures in voice and tone qualities, and build all denture surfaces as accurately as possible, in order to form the proper base upon which to set our teeth for more perfect articulation?

Phonetics is the science of articulate sound, and our modern age is replete with individuals whose livelihood depends upon perfection in this field. Today we have stage, screen, radio, television, and the clergy all demanding high quality in voice and diction. This demand we must be prepared to meet. We must recognize the fact that the answer is not just teeth and the setting of teeth, but also the development of naturally shaped dentures which will give the patient a better opportunity to utter normal sounds.

TINTING THE DENTURE BASE

The last and possibly most dramatic phase of creating the "New Look" involves the tinting of the denture base material to resemble the tissues of the mouth. One cannot help but realize the inadequacy of present denture base material as a truly esthetic replacement after studying the many colors, shades, and tones that are found in these tissues. The basic colors and the intensity of colors vary with the type of individual, but the general shading of these base colors is fairly constant. As an example, the harder and more tense tissues are always lighter in shade than the softer tissues. The gingival roll and the cuspid eminence are usually lighter than their adjacent tissues, sometimes almost white. Deeper

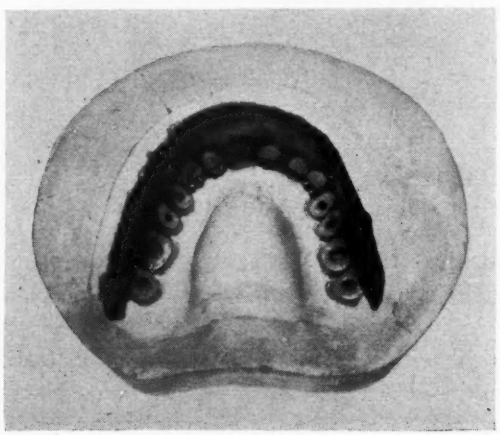

Fig. 11. — Flasked case showing the quarter inch of stone flashing about the teeth and the Replident colors applied to the labial and buccal surfaces.

red or pink tones start in the body of the papillae and extend upward fanning out into the other soft tissues or disappearing in the lighter but harder prominences. Surprisingly strong colors exist in the region of the muscle attachments and other more flexible tissues. A study of palate colors, or possibly we should say a study of the lack of color in the palate, may be of value to us when making dentures for stage personalities who must not exhibit foreign material in the palate. The important thing is that we must learn to observe and study these colors, and then do our best to reproduce them.

The first technical phase of tinting and shading a denture is to realize that the "New Look" must first be developed in the wax-up. This calls for careful study, particularly of the anatomic intricacies of the natural gingival structures and the various prominences that exist in the mouth which heretofore have not been incorporated in denture construction. In attempting to restore the natural color effects of living tissue we must remember that color is dependent on form.

Improperly fashioned dentures cannot reflect natural color schemes, and disappointment will result if this phase of the work is neglected.

Much more time is required to prepare and wax up dentures for the reception of color than actually to veneer the colors in place. The upper and lower cases must be waxed up in every detail just as the finished cases are to appear because practically no polishing can be done, or is required, after they are cured. An important phase of this detail is the required stippling. A simple way to place this stippled effect is to use a stiff toothbrush, removing all the bristles except the one tuft in the extreme end, and repeatedly stab this tuft into the wax in the desired areas. This leaves many tiny holes and flecks of wax on the high and low contours; by passing this part of the denture carefully through a low Bunsen flame, the flecks will disappear and the high spots on the wax will glaze over leaving the stippled effect where it is desired in the low spots.

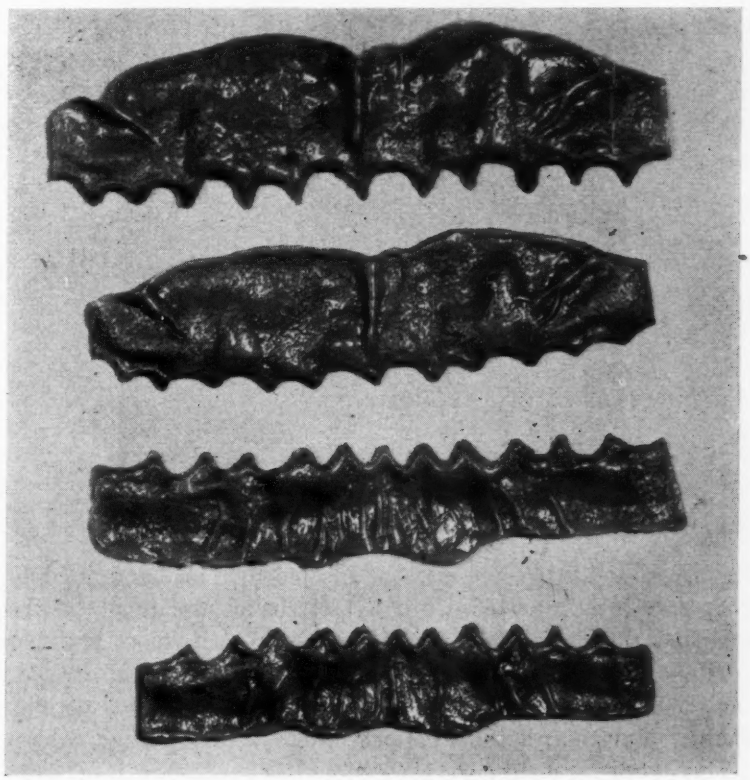

Fig. 12. — Examples of upper and lower machine-made veneers to be used in creating both anatomy and color.

After the wax-up is completed, the case is flasked in the usual manner except that a flashing of about one-fourth to one-half inch of a very dense stone is placed over the entire palate, teeth, buccal and labial surfaces of the denture. This is done before the upper half of the flask is invested. The finished denture can only be as smooth as the surface against which it is cured, so it is well to vacum the stone and paint it on the wax.

When the flasks are separated and the wax eliminated, a separating medium that is colorless and that will not take away from the detail now showing in

the stone should be applied. We have found Caulk's Al-Cote (tinted) a solution suitable for this purpose. Tin foil and the heavier separators are unsuitable only because of the loss of detail incidental to their application.

The cases are now ready to be packed, but before the base material is prepared, the colors are laid in the flask wherever they are desired. The material used for this purpose is available in a kit of eight dispenser-type bottles of different colored methyl methacrylate polymers, known as Replident. Each polymer is a finely ground colored material which can be neatly poured from its dispenser, and the different colors dispersed and blended as the case requires. Usually a layer of about 1 mm. in this granular form is applied on the buccal or labial aspects over an area of four to six teeth at a time, and then sufficient monomer is applied by instruments or hypodermic syringe to satisfy the polymer.

Fig. 13.—A practical application of machine-made veneers.

This monomer is applied at the edge of the polymer and permitted to seep into the polymer until it is saturated. The lighter shades are usually used in the first application, and this is followed by placing the other colors and blends where needed. At no time is the loose polymer permitted to pile up over 1 or 2 mm. without an application of monomer. Correctly waxed-up cases permit the operator to identify and control the locations where the respective colors are to be placed. This work is continued in sections, because this is a simple way to control the loose powder and diversify the color scheme. The palatal and other lingual surfaces can also be tinted and made to look very realistic after developing a knowledge of the colors that exist in these parts of the mouth. After the "replidenting" is completed it should be given several additional applications of the monomer. (Fig. 11.)

The balance of the packing operation can be started immediately, or at any subsequent time. Care should be taken not to overpack or subject the case to severe pressures that might tend to rub the Replident out of position. The injection method of packing is preferable but not essential.

After the case is cured and deflasked it is advisable to let the dentures soak as long as possible in a solution of sodium citrate. This will tend to break down

the small particles of stone that lodge in the many crevices, making it easier to brush or pick out. Polishing is limited to the use of prophylactic brushes on the handpiece together with a very fine polishing agent. High-speed lathes and buffers create too much gloss on the dentures and tend to eliminate some of the fine detail that has been developed.

The procedure of carving and veneering colors on dentures by hand is naturally time-consuming and requires additional skill on the part of the operator. This restricts its use to those dentists who strive for the best results, and who are able to command an equitable fee. For this reason the esthetic values of this technique can hardly reach the general public. In an attempt to simplify this procedure, in collaboration with my ingenious technician and friend, Mr. Nelson Ingersoll, Jr., a technique was developed whereby these natural anatomic contours and colors could be fabricated by machine into a flexible acrylic veneer which can easily be adapted on denture surfaces during the packing operation. When available, these veneers may be procured by any dentist or technician and will be supplied in a variety of shades and sizes. (Fig. 12.)

Their application will require no additional time or skill, and the surfaces to which they are applied will have a refreshing, natural effect both as to contour and color. (Fig. 13.)

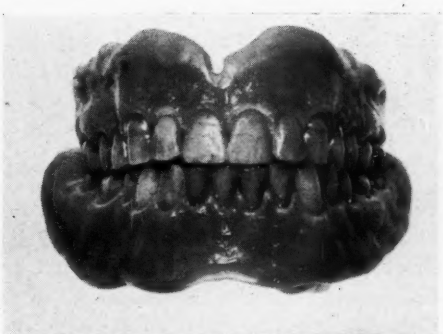

Fig. 14.—The "New Look" in action. Note the restoration of natural prominences, the full effect of the gingival tissues, and the color diversification created by contours and stippling.

CONCLUSIONS

In conclusion, it should be stated that the development of this "New Look in dentures—that speak—by themselves" can be a decided stimulus to esthetic and phonetic denistry. (Fig.14.)

Its principles are dictated by nature and are staring us in the face every day. The achievement of this result is based simply upon a determination to study nature with an open mind and then to give sufficiently of our personal time to apply this knowledge. The techniques suggested are within the reach of every dentist, and when the American public becomes conscious of this fact, plain acrylic dentures may become as obsolete as those made of vulcanite. It is hoped that others in our profession will also find that the application of these principles will bring immeasurable happiness to endentulous patients, and will remove from those contemplating replacements that fear of having to submit to an unnatural restoration affecting both speech and appearance.

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THE ACRYLIC-FACED CAST GOLD CROWN

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THE introduction of methyl methacrylate resin to dentistry has served to stimulate new interest in the full cast gold crown. This crown, widely recognized as an excellent restoration for posterior teeth, has a limited usage, for its metallic display is objectionable in the anterior part of the mouth.

While the advent of the procelain jacket crown has provided the esthetic solution, the problem has by no means been solved, since a satisfactory appearance has been frequently achieved at the expense of strength. This weakness usually manifests itself in cases presenting a deep bite, when porcelain is used over a gold-coping framework in removable or fixed partial dentures, and in tooth splinting. In the latter two instances, the establishment of proper embrasures in the framework impairs the strength of the porcelain crowns, and any compromise with the design of the embrasures violates the hygienic principles of correct construction (Fig. 1). When constructing a precision attachment partial denture, the procelain crown is open on one proximal side to accommodate the attachment. This makes it weaker than all other porcelain crowns and more susceptible to fracture.

Under certain conditions it becomes necessary to use a full crown in the anterior part of the mouth. This is the case, notably, when the teeth which should serve as abutments are badly decayed, and also are either (1) crowded in the arch, (2) rotated, or (3) present recessions and gingival wastings. In such instances, extensive preparation, short of pulp involvement, will not provide sufficient room for the necessary bulk of porcelain.

Porcelain facings as cemented inserts in the cast gold crown have also generally proved unsatisfactory. In such construction the gold is usually visible if the retention is not to be impaired. Furthermore, insufficient occlusal or incisal protection of the porcelain may induce fracture. Insufficient depth in the preparation not only impairs satisfactory retention of the facing but also fails to provide adequate thickness for correct coloration. On the other hand, baked-in facings of either low-fusing porcelain in gold crowns, or high-fusing porcelain in platinum crowns, have not proved sufficiently esthetic to be acceptable.

Thus, a suitable substitute for porcelain, particularly for use on the labial surface of the cast gold crown, has long been needed. The ideal restoration would be one which combines the advantages of the full gold casting with esthetics to equal that of porcelain. In short, a satisfactory restoration would have to demon-

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strate esthetic results comparable to those of the all-porcelain crown without exhibiting any of porcelain's disadvantages. The acrylic-faced cast gold crown fulfills these requirements.

Until recently, however, the use of this resin as a face for a cast gold crown, particularly on anterior teeth, was not satisfactory. This was because of flaws in the technique used and the lack of a full understanding of the solution of the problems involved. In general, these problems are as follows:

1. The inter-relations to be considered between tooth preparation and crown construction.
2. The safest and generally most satisfactory method for retention of the acrylic material.
3. The best way of dealing with the reflection of the metallic background in order to achieve a lifelike coloration.
4. The best method of finishing the acrylic margins.
5. The guides for the correct interpretation of any roentgenogram where acrylic is in contact with tooth structure.
6. The durability of acrylic when used in this manner.

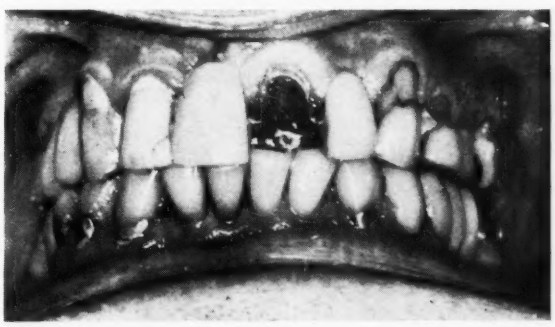


Fig. 1.—Typical result of an anterior fixed bridge, using a gold coping as an abutment. Note the improper design of the coping which invades the embrasures and thus impinges upon the interdental papillae. The gold coping shortens the height of the porcelain, with resulting weakness of the restortation which fractured frequently. The acrylic-faced cast gold crown should be the abutment of choice here.

CONSIDERATIONS OF TOOTH PREPARATION AND CROWN CONSTRUCTION

There are two basic forms of acrylic-faced cast gold crowns that can be used clinically with success. These two forms, in turn, have individual variations, depending on the needs of function and esthetics. One form is finished completely in gold to all margins of the tooth preparation; the other is finished to the labial margin in acrylic and to all other margins in gold.

The crown that is best suited to meet the individual situation is selected for use. This selection is made after the tooth is prepared. The available space for the thickness and retention of the facing, and the functional demands the restoration must meet, are best determined only after studying the relationship of the prepared tooth stump to the adjacent teeth.

For all upper teeth, except the molars, the maximum of strength and esthetics, combined, is obtained with a shoulder-shoulderless type of preparation. The

shoulder, made on the labial aspect of upper anterior teeth, need be no wider than one created by a No. 557 fissure bur. This shoulder should be carried well beneath the marginal gingiva short of the epithelial attachment and should end interproximally at a point slightly lingual to the proposed contact point (Fig. 2). This will provide, when the restoration is completed, for a contact point of gold and at the same time prevent the finished crown from revealing any metal. A contact point in gold is essential, since it insures a more accurate relationship to the adjacent teeth and also reduces interproximal wear in function.[1] When the crown serves as an abutment, gold contact is further needed to facilitate the soldering of fixed replacements and the splinting of teeth.

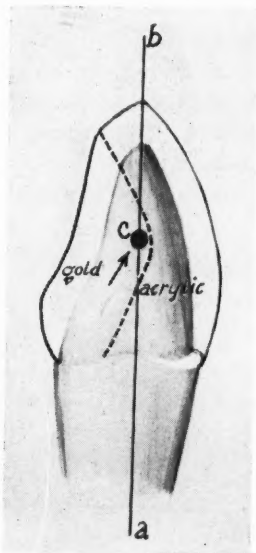


Fig. 2.—Schematic drawing to illustrate the preparation of the shoulder, carrying it to the lingual of the interproximal area. *a-b*, Line of interproximal relationship to an adjacent tooth. *c*, The approximate contact area.

Absolute sharpness of the preparation's finishing edges is essential for accuracy in the final result. The cavosurface of the shoulder portion is best treated with a well-sharpened hand chisel. A modification of The S. S. White Dental Mfg. Co. Hardbits No. 13 and No. 14 (Fig. 3), has been found particularly useful for this purpose. With the chisel held in the proper position, only a few mesiodistal sweeps are needed to produce a sharp marginal outline. Depending on the angle of application, this chisel can produce either a beveled shoulder or a right angle shoulder, as required. The bevel is used on the upper teeth when a gold collar at the labiogingival border is desired; otherwise, the square seat is used. In cases where the bevel is not used in the preparation, the gold of the finished casting is not brought to the labial margin; here the acrylic itself is carried to the labial margin.

All the lower teeth are best treated by the shoulderless preparation. Where the lower anterior teeth are large and well formed, the labiogingival portion is completed by slight chamfering. All such crowns require gold-protected margins. However, the use of a chamfered shoulderless preparation, rather than the simple shoulderless treatment alone, provides more room for acrylic at the labiogingival

area and thus reduces the amount of gold which would ordinarily be visible at the labiogingival area.

It should be noted, too, that the buccal cusps and incisal edges of all the lower teeth are the only surfaces that are adjacent to the acrylic facing in maintaining centric contact. These cusps, in addition, enter into all functional contacts regardless of jaw movement. Vertical stress, therefore, might tend to displace the acrylic facing, unless it is adequately supported. Therefore, in addition to the retention that is built into all crowns for the acrylic face, the use of the all-gold gingival band supplies the needed support to resist this stress.

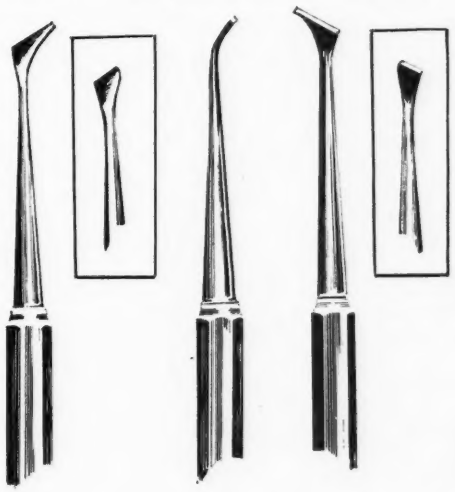


Fig. 3*A*.—Original S.S. White Hardbits No. 13 and No. 14. The inset drawing illustrates the modification of these instruments by reducing the sharp corners with a stone. When this modified instrument is used beneath the free margin of the gingiva, laceration of the tissues is reduced to a minimum.

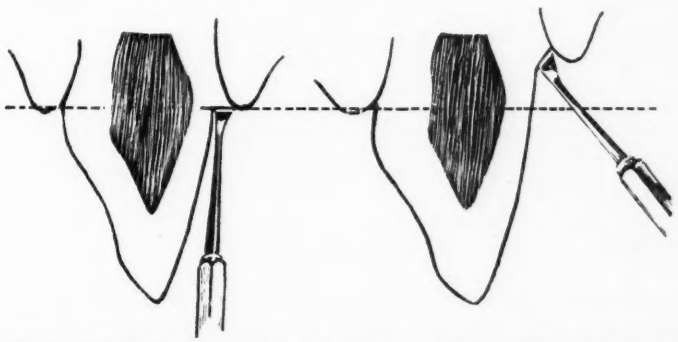
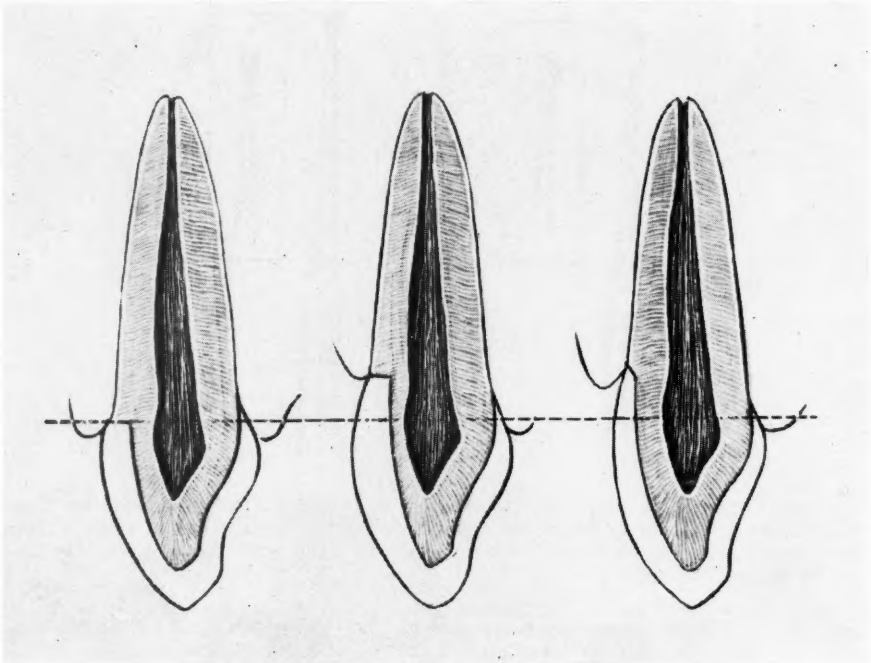


Fig. 3*B*.—When sharpening the margin of a square shoulder, the instrument is held close to the labial wall of the preparation. When the bevel type of marginal finish is desired, the instrument is positioned to the selected angle.

Furthermore, in the lower jaw esthetic demands are less frequent for hiding this band of gold. On the other hand, the facings for upper teeth require the highest degree of esthetics and a lesser degree of safeguard against this vertical stress. This is so mainly because the incisal edges and buccal cusps of the upper teeth do not enter into the centric contact but function only on incision and in the working phase of lateral protrusive contact.

Clinical variations of tooth positions in the arch such as extrusions, rotations, as well as special circumstances created by recessions of gingival tissues, will necessitate modifications of the preparations. Shoulder preparation at times must be avoided for, when a shoulder is prepared on root structure, the distance from the facial surface of the preparation to the pulp is naturally less than if a similar shoulder were made on the anatomic crown. This shoulder on the root must also be much narrower than one prepared on enamel or close to the cemento-enamel junction. In fact, preparation of the shoulder in any other manner might well endanger the pulp and, therefore, the beveled preparation is indicated (Fig. 4).



A. *B.* *C.*

Fig. 4.—*A*, Correct shoulder preparation to minimize injury to the pulp.

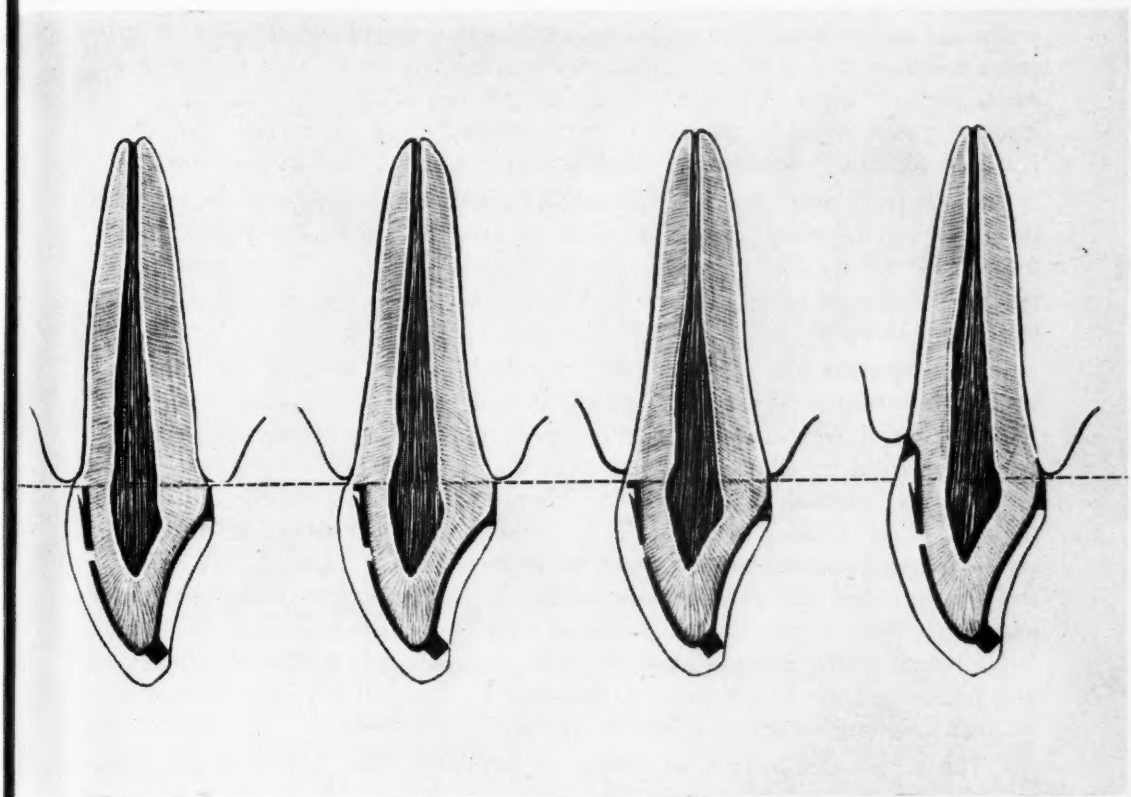
B, Incorrect shoulder treatment. When a labiogingival recession is present, the preparation of an orthodox shoulder on the labial aspect of the tooth will remove too much tooth structure for pulpal safety.

C, Correct treatment of labial recessions. A narrow bevel is prepared at the labiogingival area, thus less tooth structure is removed and the health of the pulp is better protected.

The acrylic-faced gold crown is made in two parts: one, the construction of the basic internal portion called the gold thimble; and, two, the external portion or crown proper, made by adding gold and acrylic to this thimble.

To control all steps and to assure a high degree of accuracy for the end result, the following procedure predicated on the indirect impression technique has been developed. An individual band impression is taken of the prepared tooth and a die is made by the copper-plating process. On this die, a wax thimble is then made by dipping the previously lubricated die into molten wax. The labial portion is kept as thin as technical limitations and the requirements of successful casting will permit. The lingual surface is waxed somewhat thicker and is reinforced at the gingival area to form a shoulder in wax.

When forming the thimble, a wing of wax as broad as the labial face of the preparation is placed at the labiogingival area. (This wing serves as a first step in providing retention for the proposed acrylic and also creates a ledge to facilitate removal of the thimble from the tooth.) Painstaking care is given to finishing and sealing the marginal areas. A sprue is attached to the incisal portion, the pattern is invested and then cast in the usual manner (Fig. 5). This casting is machined on the internal surface with the aid of small finishing burs and stones to remove discrepancies, and fitted to the die. With a No. 1 round bur, a hole is bored in the thimble on the labial side.



A. *B.* *C.* *D.*

Fig. 5.—Four methods of treating the labiogingival area when constructing the thimble. *A*, *B*, and *C* will, in each instance, be finished with acrylic to the labial margin of the crown proper. In each case, the objective should be to cover the maximum amount of the shoulder with gold. This will provide resistance against vertical displacement stress of the facing. The wing at the gingival area creates a positive lock in this area for the acrylic, assuring retention of the portion against tooth structure. The amount of acrylic in contact with the labial tooth shoulder should be minimal; therefore, narrow shoulders will require less gold, and wider ones, more gold. This minimal amount of acrylic makes a superior crown, esthetically, since the light transmission through the gingival area is superior to that in *D*. The gold thimble at the gingival of *D* is in an area of labial recession which usually is not visible.

The inner surface of the casting is oiled to facilitate trial of the thimble on the tooth—the hole serving for the escape of air and for checking the accuracy of the seating. Furthermore, trial of this thimble on the tooth tests the accuracy of the die as well as the retention and stability of the thimble.

There are several methods of treating the labial shoulder portion of the thimble when forming it in wax. Where the preparation calls for a gold gingival collar protection, the entire labial portion is formed as a wax collar, continuous with the lingual wax shoulder. However, if there is the possibility that such a collar on an upper anterior tooth might be visible on smiling or speaking, then acrylic should be used to the labial margin.

When acrylic is needed to satisfy such esthetic needs, there are three acceptable ways to wax the thimble at the labial shoulder. The wax is brought to the labio-axio-gingival line angle or to a point midway on the shoulder or almost to the very margin (Fig. 5). The selection of any of these variations depends on the width of the shoulder. The objective is to form a supporting shoulder in gold and a finishing edge in acrylic. Narrow shoulders require the first type of treatment, whereas wider shoulders use one of the two other variations. In every instance, *unless sufficient space exists for a minimal labial thickness of the acrylic* it will be difficult to produce a good color at the gingival third of the crown.

Similarly, if insufficient space exists on the labioincisal portion of the preparation, opening this thimble labially offers an alternate type of treatment to the full thimble for the internal portion of the crown (Fig. 6). In the presence of less than a minimal labial thickness of 1 mm., a successful color match can hardly be achieved unless the open thimble is employed.

The objection to the use of the open gold thimble window has been that the cement behind the acrylic face is likely to disintegrate, if it lacks gold backing.* Examination of 76 such acrylic-faced crowns, removed after some five years of service, revealed no clinical evidence to substantiate the above criticism. These crowns were removed because of color failure attributed to a chemical change in the color of the masking material. In fact, without a single exception, the cement was found to be intact and the tooth structure apparently normal. It must be stressed, however, that in all these cases *the acrylic facing was properly retained within the gold crown.* (The technique used is described later.) Inadequate facing retention may permit leakage between the acrylic and gold, with subsequent discoloration of the facing, possibly followed by dissolution of the cement and ultimate loosening of the crown from the tooth.

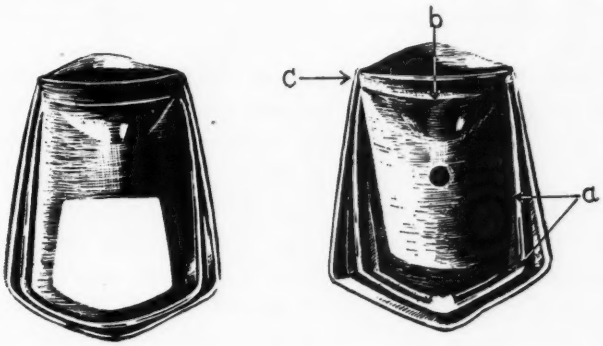
The acrylic-faced cast gold crown, as here described, has adequate facing retention by virtue of the design of the metallic thimble. This thimble itself must be constructed in such a manner that it will manifest stability and retention when tried and tested on the tooth. There is no better way of assuring future resistance to functional stress. It should be especially noted that, when the open thimble is used, the labiogingival band portion of the gold thimble must be as broad as possible. The cutout portion must not extend onto the mesial and disto-axio-labial angles, while the incisal portion of the thimble must extend around to the labial and grasp the tip (Fig. 6). In this manner resistance form is assured. This form

*When acrylic material is used for complete crowns, without benefit of a metal backing, there is always the danger that they may loosen. For an acrylic crown, being flexible, is likely to "give" under stress. When this occurs, the cement may crack and permit seepage of mouth fluids through the margins. This, in turn may lead to further dissolution of the cement and ultimate loosening of the crown from the tooth.[1, 5]

once established and tried on the tooth for retention must not be modified, or the retention may be impaired.

To construct the gold thimble on any other principle would be hazardous, since it is of prime importance to prevent the thimble from springing when the tooth is in function. Such springing movements would tend to crack the cement, and probably lead to its eventual dissolution. Essentially, an internal gold crown is being constructed—one which becomes an internal open-faced gold crown when the thimble is opened labially. Correct construction for the open thimble results in a finished crown that is equally resistant to all displacement stresses, as though it were a finished crown employing the completely closed thimble.

Generally speaking, since light is so well reflected by acrylic,[1] it may be said that the most esthetic crown is more easily produced when the entire shoulder and the incisal tip are free of metal, and the internal gold portion is constructed on the open thimble principle.



A. *B.*

Fig. 6.—The open and closed gold thimbles. The open thimble crown grasps the mesio-disto-inciso-labial areas. The ribbon loop (*a*) connects with the labiogingival wing (*b*). At (*c*) the gold and acrylic end in an area of width and depth. Locking of the acrylic into the gold in this region is of paramount importance. The acrylic must not meet the gold and form a knife edge in this region, or seepage is invited.

RETENTION OF THE ACRYLIC FACE

Esthetic considerations are decisive in determining the manner of retaining the acrylic material within the gold framework. Obviously, the simplest form of retention would be the lap rim. Esthetics, however, demand that no gold show interproximally or gingivally in the finished product. Therefore, lap-rim construction would not meet the esthetic requirements to a sufficient extent or be any better than most porcelain facings.

After the thimble is tested on the tooth, and the fit and retention are judged as correct, the plaster-relationship impression is secured with the gold thimble in place. No die is inserted into the cast thimble before the stone cast is made. Instead, a seat is created by pouring low-fusing metal into the inner surface of the previously antifluxed thimble while it is still in the impression, as well as into the impression of the natural teeth adjacent to the thimble.

When the cast is completed the thimble is removed and cleansed in acid, and the low-fusing metal seat is oiled to prevent the gold thimble, upon return to the

cast, from becoming contaminated, subsequently, by the low-fusing metal. The sprue is removed and the outer surface of the thimble trimmed and undercut, wherever necessary. Wax is then added to the thimble to complete the crown and bring it to the desired anatomic form. This crown may be tried on the tooth in the mouth for approval of the form and to suggest any possible additions or subtractions to be made in the wax. When the form is approved, the wax crown is returned to the cast for completion of the crown.

An artificial stone index of this finished wax form is taken on the cast and put aside for use when finishing the crown. The facial surface of the wax is then cut so as to expose the labial aspect of the gold thimble. Interproximally, this cutout is carried to the lingual as far as the shoulder has been prepared. This brings the wax cut to the contact point and thus ultimately provides for the desired contact in metal (Fig. 2). Above and below the proposed contact point, the wax is further cut to the lingual so that the resultant casting, when finally processed with acrylic, will show no gold, either proximogingivally or incisogingivally, above or below the contact point.

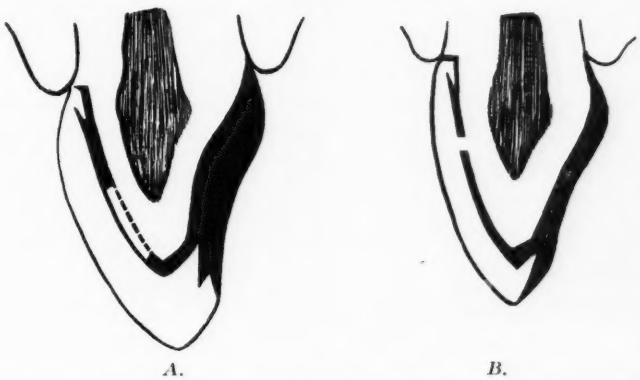
Where the crown is bulky, more wax is cut out until the gold thimble is further exposed in other areas. Thus either incisally or occlusally, as well as mesially and distally, hollows are made which lie between the original thimble and the outer wax surface of the crown. When the casting is complete, large undercut areas are thus produced; these add substantially to the retention of the acrylic veneer material, and appreciably lessen the weight of the crown.

To prevent the acrylic from finishing to a knife edge where it joins the gold at the proximogingival margins, it is important that the *cutout end in areas where width and depth both exist.* Adequate retention and locking of the acrylic in this area is paramount *since the junction of both materials form the margin at this point.* Insufficient retention may permit the acrylic to creep away from the gold, with resultant marginal failure. While usually this can be anticipated when the thimble is constructed, verification that such an area exists is imperative at this time (Fig. 6).

The incisal edge is then treated in one of two ways, depending on the functional stress which may be applied to the incisal tip. When there is a deep overbite, or when the restoration occludes against a natural tooth, the entire lingual surface should be covered with gold to the incisal edge, forming what is known as a "blind tip." On the other hand, with a shallow overbite or when the anterior teeth do not enter into the centric occlusion as in an overjet, or when one crown occludes with another, the tip is free of gold and the incisal edge is made of acrylic material (Fig. 7).

Two small pieces of the thinnest gauge round wax are luted to this pattern at a point just beyond the axial angles of the gold thimble and as far to the lingual as it is carved (Fig. 6). The wax crown is *invested together with the gold thimble,* and cast. When the casting is completed, the junction between the thimble and the final casting is soldered to assure a perfect joint. As a result of investing the thimble and casting against it, there may be produced a rough inner surface on the thimble. In addition, occasionally, this thimble may shrink slightly. The two factors, combined, may prevent the final crown, as it comes from the casting process,

from fitting the original die. Therefore, the internal surface of the crown is again machined until discrepancies are removed and the fit is secured. After these procedures, the mesial and distal extremities of the window are grooved and undercut with a wheel bur. If such a bur is unobtainable, an inverted cone bur may be used (No. 33½), or possibly even a bur of that kind (No. 35) reshaped into a wheel by flattening its face. The resultant undercut is designed to create a lock between the ribbon loop and the periphery. The labial surface is then scarified, and accessory or supplementary undercuts are made wherever possible. This not only materially aids the retention of the facing itself, but also results in a rough surface which favors the adherence of the masking material.



A. *B.*

Fig. 7.—Schematic drawing to illustrate treatment of the incisal edges. In every instance the incisal lock is antagonistic to the gingival lock. Together with the ribbon loop illustrated in Fig. 6, adequate locking of the acrylic is achieved in all areas. This retention is important in securing a successful veneer.

MASKING AND COLOR

The present consideration of the subject of masking and color will be limited to a discussion of only a few of the problems peculiar to acrylic-faced gold crown construction, and a brief mention of the methods employed in overcoming some of the difficulties inherent in the process. The problems to be considered pertain not only to the construction of the acrylic-faced crown but also to the more general use of methyl methacrylate resin for dentures on a metallic base.

Each of the points to be discussed is of major importance to the perplexing problem of achieving the optimum harmony in color.

Acrylic material is translucent. The various manufactured products differ in degree of coarseness and opacity, according to the amount of pigment and the fineness of the powder. Some products come in premixed shades, others in basic shades. Originally, they were intended to serve not as a facing but as material for either a jacket, a denture tooth, or an inlay. Therefore, the manufacturer's recommendations as to shades do not, as a rule, produce the desired result when used in a gold crown.

Consequently, test shades must always be made against the actual metal background to be used in the finished casting. All samples should be made to a minimal thickness of 1 mm. The sample is matched to the teeth in the mouth, preferably with the sample resting on the prepared tooth. For study, the sample is affixed

to the tooth with Moyer's* clear counter wax. This wax will not influence the color; it is moldable at room temperature, and is tacky on the dry tooth. Since we do not hold the sample, judgment of the harmony of the color is simplified by viewing it in a position natural to the lips and gingivae. All samples should be saved and the formulas noted. This will reduce the future need for new samples and the time required for shade selection. This sample is invested with the case to be processed. Processing is then reduced to copying the sample, using the same powders and formula.

Nothing much is gained if the dentist goes to the trouble of making a sample and then fails to invest it with the crown or case to be processed. The investing medium used in flasking is bound to influence the color sense of the operator processing the crown.

Any given sample, which matches the natural tooth, when placed at or near the prepared tooth will look entirely different when invested in the flask. Any deviation or change in the color selection of the powders in the course of the processing could lead to a less satisfactory result. Attempts to match a sample, free hand, without troubling to place it in the flask may also produce an unsatisfactory result. If a critical evaluation of an accepted sample is desired, investing and copying it is the safest procedure.

Another point worthy of special note is that acrylic material, processed into a gold backing without the use of some means of masking the gold, will result in a lifeless-looking crown. Various masking materials are recommended and commercially produced. Some commercial products preclude the possibility of achieving a good marginal seal, and then either disintegrate or oxidize, generally turning the facing brown, gray, or black (Fig. 8). Other recommended products fail to meet the requirements of a satisfactory masking medium.

Masking materials should be chemically inert, relatively insoluble, and not susceptible to attack by acrylic monomer or the mouth fluids. Of all the masking materials the writer has used, oxyphosphate of zinc cement powder has produced the best and the most durable results. Acrylic-faced cast gold crowns, made nearly ten years ago with oxyphosphate of zinc cement powder as the masking base, are precisely the same shade today (Fig. 8). Most other crowns, in which commercial masking materials were used, failed to demonstrate the same results.

The use of cement powder serves another valuable purpose in that it provides a color which approximates that of natural dentine. Any variation of color to be used is predetermined by the operator. The color used for the gingival region need not necessarily be identical with that used for the incisal region. In addition, different colors may be used for different teeth in the same mouth. Steele's Super Stains are used as concentrates in modifying the basic shade of the cement powder or for introducing stained effects in specific areas, as indicated. Thus, by using a variety of masking backgrounds together with one set of gingival and incisal acrylic powders, variations of hue that look natural can be achieved.

*J. Bird Moyer Co., Inc.

J. PROS. DENT.
VOL. 1, NOS. 1 AND 2, JAN. AND MARCH, 1951

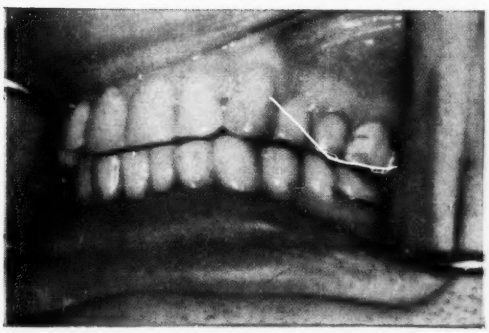


Fig. 8*A*.

Fig. 8*B*.

Fig. 8*A*.—Upper left fixed bridge with acrylic-faced cast gold crown abutments. These crowns were constructed with a commercial masking material as the opacifier. Note the grayish-black discoloration which occurred after one year. The upper left and lower left first molars were made over nine years ago, using a cement-acrylic opacifier. The color remained unchanged over this period of time.

Fig. 8*B*.—Another example of marked discoloration. The lower right first bicuspid turned a deep brown within two years. This crown was also constructed with the same masking material used in Fig. 8*A*. The upper right first bicuspid crown, placed at a later date, is also beginning to turn color. Note, however, the lower right second bicuspid crown, which was constructed as described in the text, has not changed color in three years. The method for securing retention of the facing and the acrylic material used were identical. The only variable is the opacifier that was used.

The cement powder is mixed with acrylic powder of the basic gingival and incisal shades selected for the case. The mixture is one composed of equal parts by volume of acrylic and cement powder. This powder is wetted with monomer, thoroughly spatulated, and painted with a fine camel's-hair brush onto the slightly warmed gold surface, then allowed to dry in the air, and set overnight. Where time is a factor, equally good results are obtained by using an infrared lamp to hasten the setting of the masking paint. This opaque layer must be allowed to set, otherwise it will be displaced when adding the bulk of other powders to complete the crown.

Despite the manufacturers' recommendations to the contrary, the dry-packing method is preferred. For one thing, it is the simplest method available, and it permits the addition of a variety of small batches of colors in specific areas which will blend with the basic gingival and incisal shades, as these are being applied. The dry-packing method is used because color is being copied, since we cannot reproduce a stock shade of the bottled product in an acrylic-faced gold crown. The basic colors are packed first; then after the first test pack has been studied, small portions of the semicured material are gouged with a small cuticle cutter from the areas we wish to characterize further. This process of semicuring and gouging is repeated until the desired result is obtained.

The cement acts as an opacifier and thus tends to block out the color of the cast gold, which would otherwise be markedly reflected through the acrylic facing. Despite this precautionary measure, however, many crowns appear lifeless under certain lighting conditions. Most commonly, the undesirable tinge is grayish or bluish—attributable, of course, to the color of the metallic background, which the cement powder does not fully mask. Although known as "gold" the color of these alloys leans toward the gray or grayish yellow. As is known, alloying is a necessity since it imparts to gold the indispensable qualities of hardness, tensile strength, and elongation. The grayish cast of the shades results from the use of these alloys.

But where this gray hue is undesirable, we must resort to some other means. Pure gold, unlike the gold alloys, reflects a pink or golden background with a richness that pleases the eye. The problem, therefore, is to achieve the pure gold effect even when alloys are used. And this can be done by the simple procedure of *flash gold-plating* the entire crown or bridge, *without changing the required quality of the casting gold.* Any plating apparatus may be used, the process takes only a moment. No precautions need be taken to prevent a fine gold deposit from forming on any part of the prosthesis. The film that is deposited is exceedingly thin; and final polishing readily and completely removes the fine gold deposit from all areas that will later be visible in the mouth.

Variations in the color of this plating can be created either by changing the amount of current, the temperature of the solution, or the duration of the immersion. In this manner it is possible to obtain a variety of colors, ranging from light brassy to a deep bronze gold. Since the color of the plating is bound to influence the final result, it is always well to decide on the hue when the sample is being made (Fig. 9).

Three basic modifications of color for finished acrylic faces can thus be secured with the use of plated or unplated backgrounds: a gray modification, a yellow modification, and a red modification of any one set of gingival and acrylic shades

(Fig. 10). By using the gingival of one shade and the incisal of another, numerous further variations can be made.

When the acrylic is to rest against tooth structure, the copper die is also flash gold-plated in order to prevent oxides or sulfides from being processed into the acrylic.[2]

The color of these acrylic-faced crowns is equally good in natural sunlight and in artificial light. Thin areas of acrylic reflect golden tints and thus give the appearance of yellow opacities or stained effects. This is not true of unplated backgrounds. Occasionally, the loops for retention are of necessity close to the outer surface of the facing. When plated, however, these loops will blend with the acrylic, to resemble the vertical striations seen in a natural tooth.

Color can be accurately evaluated by studying Kodachrome reproductions of natural and artificial crowns (Fig. 11), combined in the same illustration. Comparison in this manner is likely to be more revealing than inspection by direct vision. Both mirrow-viewing by the patient and color transparencies are likely to reflect discrepancies which are not readily seen by direct vision. The final test, of course, is whether or not the restoration looks natural to others when viewed in its ultimate environment.[3] Acrylic meets this requirement to a high degree, since light is well reflected.[3]

It may be said here that, with the described technique for acrylic-faced crown construction, it is possible to produce esthetic restorations comparable to, and sometimes surpassing, the results achieved with porcelain (Fig. 11).

FINISHING AND CEMENTING

When a gold casting is completed, it is refined and polished, then flash gold-plated and returned to the cast. The index of the original wax-up is then replaced on the cast. White inlay wax is used for filling the window and the final form of the crown is approved. The finished wax-faced gold crown is then invested with the gold-plated die. Processing directly on the gold-plated die serves the double purpose of preventing metallic contamination[4] and assuring maximal accuracy of fit at the labial shoulder. No attempts should be made to draw the wax pattern from the die and to invest it in a stone medium. Such procedures generally result in defects which, though minor, will make it impossible to achieve the accuracy required of the finished margins. When waxing up, however, a slight excess must be allowed to permit careful machining of the margins. The excess

Fig. 9*A*.—*a*, Heavy plating. *b*, Unplated casting. *c*, Light plating.

Fig. 9*B*.—A denture base of palladium alloy plated with gold on one-half of its surface to show change in surface color. A cast gold ingot similarly treated and processed with denture acrylic the thickness of one sheet of baseplate wax. Note the difference in color resulting when the background is gold-plated. The color of this gold-backed acrylic and denture acrylic without gold backing is almost identical.

Fig. 10.—The results of flash gold-plating. Three different colors can be secured: (*a*) heavy plating, (*b*) unplated, and (*c*) moderate plating. This results in a red modification at *a*, a gray modification at *b*, and a yellow modification at *c* of any set of gingival and incisal acrylic powders selected for use. The illustration shows shade 65 New Hue and the variations of color secured by this treatment. The thickness of the facing, the masking medium, and the distribution of the acrylic powders used were identical. All three crowns were packed and processed at the same time. The only variable was the color of the gold, modified by flash gold-plating, the selected casting metal used in making the crown.

a. *b.* *c.*

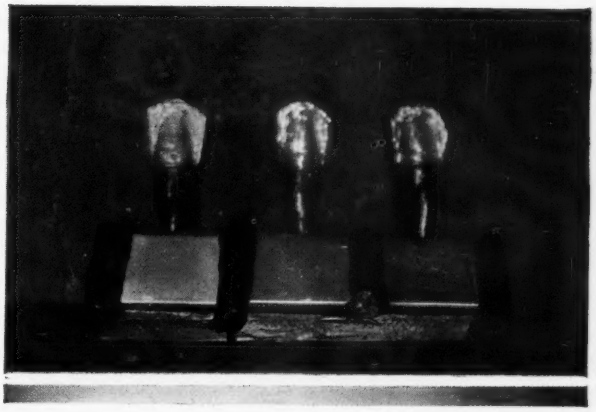


Fig. 9*A*.

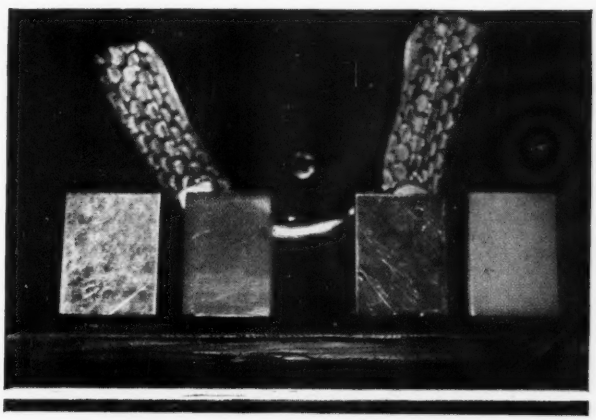


Fig. 9*B*.

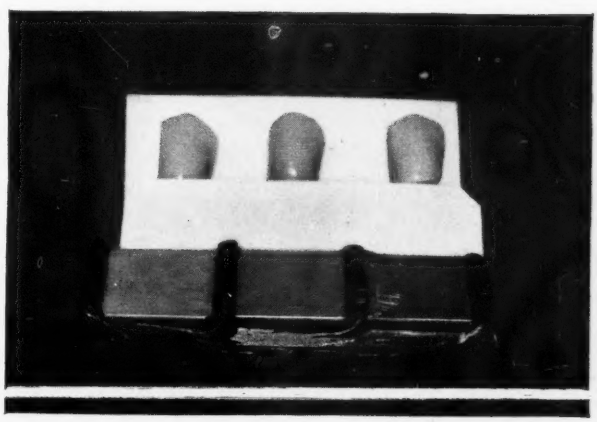


Fig. 10.

a. *b.* *c.*

(For legend, see opposite page.)

acrylic extending beyond the margin is readily detected, since acrylic is almost transparent in areas where it is thin, and will consequently disclose the apron of the die. The margins of the die are very distinct, therefore, and the finishing job is considered completed when this translucent excess is no longer seen. With this technique, an acrylic margin, finished and polished to the die, should result in flawless fit on the prepared tooth. In fact, the finished shoulder in acrylic is superior to one of porcelain, because construction of the latter requires the use of platinum foil. When this foil is finally stripped from the completed crown, the latter's internal dimensions are inevitably increased, which means, of course, that the crown will not fit perfectly.

The finished crown or case should be stored in water for two to three weeks, to promote water absorption and compensate for shrinkage because of curing.[1, 5] It is best to keep the water at mouth temperature. In addition, it is further advisable to insert the case in the mouth for a minimal trial period of a week. A very thick creamy mixture of oxyphosphate of zinc cement powder and white petrolatum is prepared, placed into the crown, and the crown is inserted on the dried tooth. To eliminate pain and assure accurate seating, the restoration should be well warmed and the petrolatum mixture softened by heating with a warm-air syringe. The use of this temporary cement affords an opportunity to select the final color of the cementation medium, and also serves to seal the restoration temporarily. No appreciable leaching of this petrolatum-cement powder takes place in the short interval of a week as long as the retention and marginal seal can properly retain the restoration without any cementing medium.

The selection of a correct color cement is imperative, particularly in those cases where the crown has been constructed with acrylic to the labial margin and opened on the incisolabial third.

The cementing procedure requires painstaking treatment of the gingivae in the area under construction. The objective is to prevent tissue from bleeding, seeping, or sealing itself off between the restoration and the prepared stump, in the course of the cementation (Fig. 12). The region in question must be thoroughly inspected for any possible evidence of encroachment of the tissue over the prepared margins, particularly onto the shoulder. Even in a short period of time, temporary crowns can very easily create some irritation and hypertrophy of the gingivae, either because of an imperfect fit or because the margins of the temporary replacements have been inadequately finished. This serious contingency can be reduced by having the patient wear the finished restoration before undertaking the final cementation. If the crown is an abutment of a fixed appliance, temporarily cementing this restoration will also serve to assure us of correct adaptation of the replacements to the underlying tissues.

The final step is the cementing of the crown. To control excessive salivation due to pain, Novocain anesthesia is sometimes needed. In all instances it will be necessary to perform the following:

1. Cleanse the tooth with carbon tetrachloride.
2. Lightly pack the gingival border adjacent to the preparation with adrenalin for at least five minues.

Fig. 11*A*.—Practical case of a complete reconstruction of the occlusion. The only teeth which have not been prepared are the patient's upper right central and later incisors. All other teeth are acrylic or porcelain. The upper left central, lateral, and canine, and the right canine are acrylic-faced gold crowns. The upper missing teeth, namely, the bicuspids, are fixed bridge pontics. The lower left bicuspids and all the lower right bicuspids and molars are porcelain diatoric teeth set with denture acrylic on a palladium gold alloy base. The lower left canine and lateral and the lower right first bicuspid are acrylic-faced gold crowns; all other lower anteriors are pontics on an anterior fixed bridge. Note the fidelity of coloration between the full porcelain tooth, the comparatively thin venere of acrylic on the cast crown, and the fixed pontics which are full tooth thickness. The color of the denture pink over a white metal partial denture base is achieved by the same gold-plating method as outlined in the text. (See Fig. 10).

Fig. 11*B*.—Acrylic-faced cast gold crown on the upper left central incisor faithfully duplicates the adjacent natural incisor.

Fig. 11*C*.—The only teeth that have not been restored are the lower four incisors. The lower cuspids are gold crowns with acrylic facings. The upper right central is a pontic and the other anterior teeth are acrylic-faced crowns. Note the yellow opacity at the labiogingival area of the upper left lateral incisor. This is a section thinner than 1 mm. The fidelity of color between the acrylic-faced gold crowns and the porcelain posterior teeth in relation to the natural teeth should be noted.

Fig. 11*D*.—A controlled clinical experiment to show the difference between the ues of a plated and unplated technique in acrylic-faced crown construction. Two identical bridges were constructed in the maxilla. The lateral incisor and bicuspids were missing. The abutments are the first and second molars, and the canine teeth. Both bridges were constructed with the same acrylic and designed identically to equal thickness. The masking agent used was cement powder and acrylic powder of equal portions. The only variable was the gold-plating technique. Upper left, unplated; upper right, gold-plated. The superiority of the color in the plated bridge is obvious.

Lower acrylic-faced crowns made with a commercial masking background have discolored.

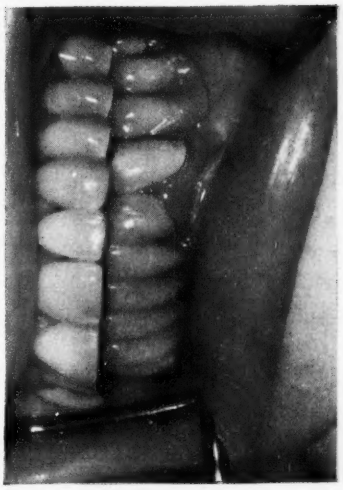


Fig. 11*A*.

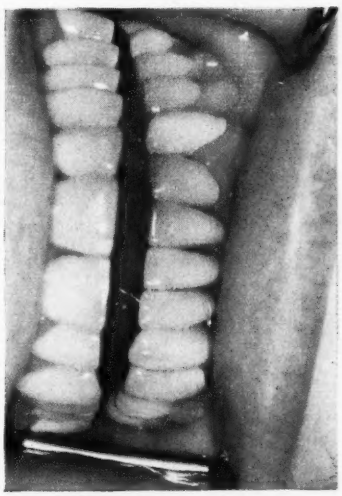


Fig. 11*B*.

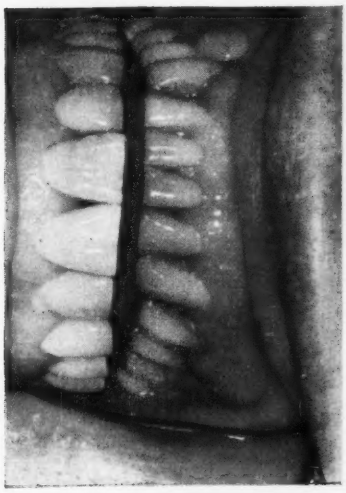


Fig. 11*D*.

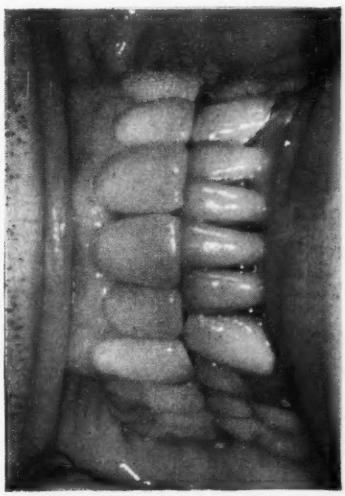


Fig. 11*C*.

(For legend, see opposite page.)

3. Touch the exposed shrunken gingival tissue with 10 per cent trichloracetic acid.

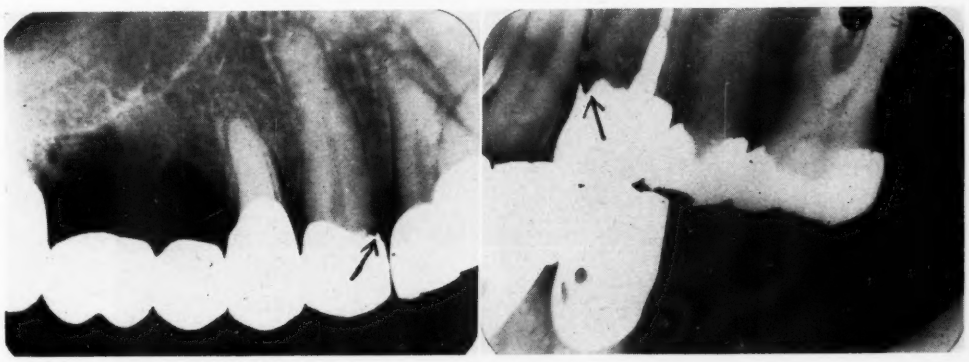
4. Dry and sterilize the tooth.

5. Varnish the tooth short of the margin.

These measures should arrest the seepage from the subgingival tissues and should also shrink or remove any small amount of tissue that may project over the cavosurface. If this treatment proves insufficient, cold cautery is then advisable.

The restoration is first filled with a slow-setting mix of oxyphosphate of zinc cement. Then the prepared tooth is gently wiped with cement, the wiping always being in the direction of the gingivae. The above procedures will generally prevent the bleeding or gingival seepage that may accompany cementation.

The restoration is then seated on the tooth. The cement contained within the crown will coalesce with the cement on the tooth. The flow of the cement will force the gingival cuff away from the restoration, as the pressure of seating the restoration brings the crown to the margins of the prepared tooth. The area is next covered with "dry foil" to protect the excess cement from saliva.



Left *Right*

Fig. 12.—Cemented acrylic-faced gold crowns in which a portion of the marginal gingivae was pinched under the crown during cementation. Note resultant caries. This radiolucency is not to be confused with the radiolucency illustrated in Fig. 16. The opaque line in this example does not extend to the very limit of the tooth contour; therefore, the tooth is not sealed, and the diagnosis of caries must be assumed.

Biting pressure with a cottonwood stick is now introduced and maintained until the cement is firmly set, assuring accurate adaptation of the parts. The surplus cement is chipped off with the aid of a sickle explorer, flattened on its sides and sharpened to simulate a scaler. Lastly, compressed air is used to deflect the gingivae and permit direct inspection of the subgingival area for assurance that all excess cement has been removed. Final checking is done by roentgenographic interpretation.

ROENTGENOGRAPHIC INTERPRETATION

Acrylic material is highly radiolucent. Its degree of radiolucency is such that the usual roentgenogram of a crown cemented with Kryptex will show neither the cementing medium nor the crown (Fig. 13, *A*). It is important that the finished cementation show some radiopacity at the marginal areas. For unless such opacity

is present, we cannot be sure that the joint is duly sealed (Fig. 13, *A, B, C*). Therefore, since the labial shoulder is acrylic, wholly or in part, the use of zinc oxyphosphate cement is recommended for all cementation in order to make sure, roentgenographically, of showing a sealed joint.

The presence of opacity, caused by the cement, is not to be interpreted as a sign of poor fit, but on the contrary, as an indication that the fit is correct (Fig. 14). Metallic restorations will show evidence of a cement line *only when cemented incorrectly* or when the restoration does not fit. With methyl methacrylate, however, the opaque area created by the cement marks the amount of acrylic in con-

Fig. 13.—*A*, Roentgenogram of acrylic crowns cemented with Kryptex. No radiopaque border is visible on the tooth. For diagnostic purposes, it is important that the cementing medium be visible on the film.

B, Acrylic crowns cemented with oxyphosphate of zinc cement. The line of junction can be traced about the shoulder because of the opacity of the cement.

C, The distal surface of the right central incisor has a self-curing acrylic restoration, whereas the distal surface of the right lateral incisor has an untreated carious involvement. The difficulty in making a differential diagnosis roentgenographically is obvious.

D, A thin coating of oxyphosphate of zinc cement is all that is needed to differentiate between recurrent decay under a restoration and one that is caries free. The mesial surface of the upper right lateral incisor is restored with a self-curing acrylic restoration. Note the complete radiolucency of the restoration and the radiopacity of the cement lining.

tact with tooth structure. However, the opacity that registers on a film varies in density, and interpretation will depend on the following considerations (Fig. 15):

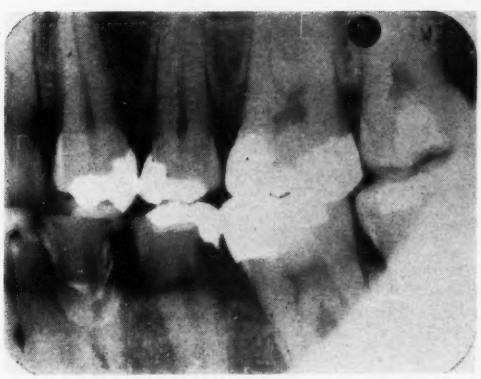
1. The thickness the cement forms between the acrylic and tooth structure: namely, the variations in thickness of the cement film.

2. The width of the cement measured from the external margin to the internal margin of the shoulder: namely, the width of the cement in contact with the shoulder of acrylic and tooth structure.

3. The angle of this shoulder: namely, the angulation this cement film forms from the horizontal.

4. The curvature of the shoulder: namely, the curvature the cement film makes, following the contour of the tooth.

A. *B.*



C.

Fig. 14.—*A*, Acrylic inlays cemented into the buccal surfaces of the left upper and lower bicuspids five years ago. Note the fine opaque line of marginal demarcation. Note also that the opaque line ends at the tooth contour on the lower left second bicuspid. The radiolucency above the opaque line is the acrylic restorative material which replaces the lost tooth substance.

B, The lower left second bicuspid has a buccal acrylic inlay cemented against a disto-occlusal gold inlay. Note that the opaque lines join the metallic restoration to make a continuous joint. In the restoration placed in the buccal surface of the first bicuspid, note the increased density at the distoproximal surface where the roentgen rays, passing through the marginal outline of the inlay, register the linear depth of the opaque cement. Here the rays were parallel to the cement film.

C, On the opposite side of the same mouth as in *B*, the first bicuspid buccal inlay made of acrylic shows a different registration because of differences in the level of the marginal outline. The second bicuspid inlay, cemented with Kryptex, is particularly difficult to diagnose from a study of the roentgenogram.

5. The lateral and horizontal angulation of the roentgen rays in relation to to the perpendicular axis of the tooth.

Since a roentgenogram registers a three-dimensional object on a single plane, the roentgen rays parallel with the cement film will show greater opacity. This measures the linear depth of the cement film and shows on the roentgenogram as an opaque line (Figs. 14-16). Since a cement film is usually quite thin, other areas in relation to such an opaque line will appear relatively radiolucent, particularly if such areas are immediately adjacent to the maximum registration of opacity due to the gold of the crown.

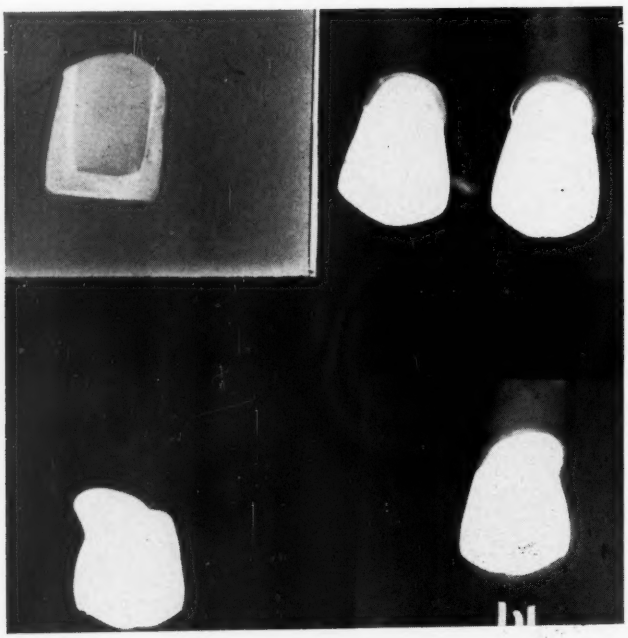
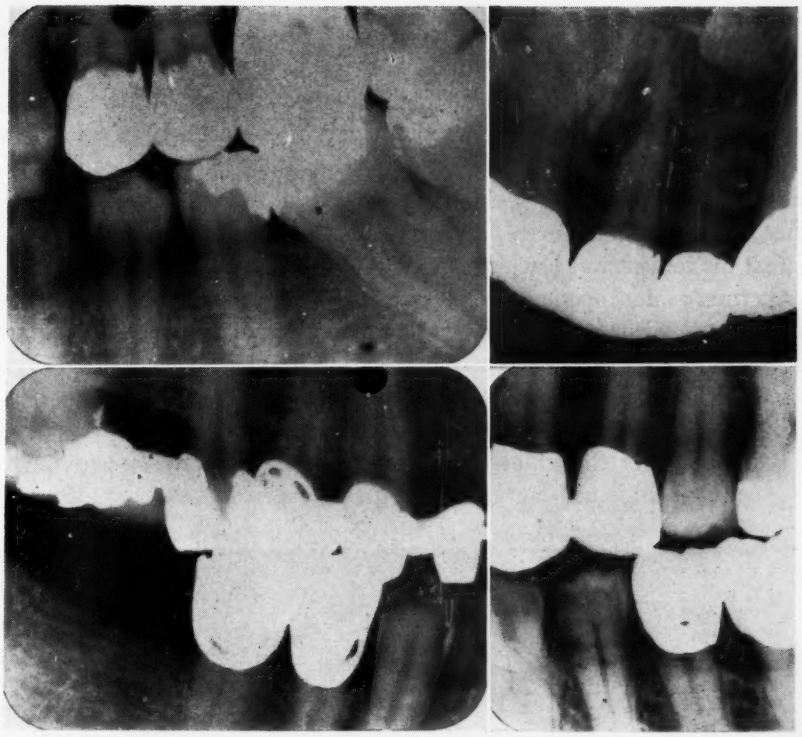


Fig. 15.—Experiment to show the relationship of the opaque cement film to the shoulder preparation when acrylic is used in contact with the tooth shoulder. An Ivorine tooth was used in the construction of several acrylic-faced cast gold crowns. Some shoulders of acrylic were wider, as in *B*, and others were very narrow, as in *D*. In *C* the acrylic was carried beyond the tooth contours to simulate an overhang. The other crowns used in the illustrations were finished to the margin. These crowns were cemented to the Ivorine tooth and roentgenographs taken from various angles to study the cement-film relationship to the shoulder portion not covered by the gold. In addition to these crowns, a facing was made on a gold backing without any retentions. The facing was removed from the backing, and the backing coated with a very thin film of oil. The acrylic facing was then cemented to this backing. After thorough hardening of the cement, this facing was removed carefully from the backing without disturbing the cement. A curved acrylic facing with a layer of oxyphosphate of zinc cement was obtained, as in *A*. A roentgenograph was taken at right angles to the facing for the study of the relationship of the curvature of the facing to the opaque cement film.

In *A*, note the varying densities of the cement film and the areas of greatest opacity where the curvature of the facing is almost a vertical line. Note, too, that on the flat aspect of the facing the opacity is not even. The relative differences in the density might lead one to believe cement was present only in the opaque areas. Visual inspection, however, verifies the presence of cement all over the acrylic facing, in varying thicknesses.

B, therefore, simulates the natural condition of cementing an acrylic-faced cast gold crown on a tooth. Note again the variation in the registration of the radiopacity. In *C* the opaque line is beyond the tooth contours, and at *A*, with the narrow contact of acrylic material with the Typodent shoulder, the opaque line is very thin.

A. B.



C. D.

Fig. 16.—Correctly finished margins of acrylic-faced cast gold crowns. The labial acrylic margin can be traced by the opaque cement line from the perimeter of the gold to the root contour.

A, The upper right first bicuspid has a broad shoulder in acrylic. Note the opaque line and the radiolucent area between the very opaque gold crown and the labial margin.

B, Upper right central and lateral incisors. Very narrow acrylic contact with tooth structure.

C, Upper left canine. A broader contact with tooth structure.

D, Upper right first bicuspid. Note sharpness of distobuccal acrylic and tooth contact.

Fig. 17. Fig. 18.

Fig. 17.—Overfinishing of the margins of acrylic will show a deficiency at the finishing line. This will reveal itself as a notched effect between the gingival border of the crown and the finishing line.

Fig. 18.—Acrylic extended beyond the crown preparation is revealed by the opacity of the cementing media.

The opaque line, therefore, that stands out roentgengraphically as an opacity appears to be the outer edge of the acrylic facing in contact with the labial margin of the tooth shoulder (Fig. 16).

This opacity, therefore, gives assurance that the seal exists; its absence from any future film would have to be interpreted as a danger signal, and as a clear indication that the cement was leaching.

Furthermore, this opaque line is not to be interpreted as an overhang, or deficiency. A deficient margin of acrylic to tooth structure will temporarily fill in with cement and appear as a broad area of opacity and not as a line. This area will subsequently disappear and leave a concavity between the restoration and the tooth (Fig. 17). On the other hand, an overhang of acrylic will carry the cement beyond the contour of the gingival preparation, and here the opacity will show as an extension which is *not continuous with the tooth contour* (Fig. 18).

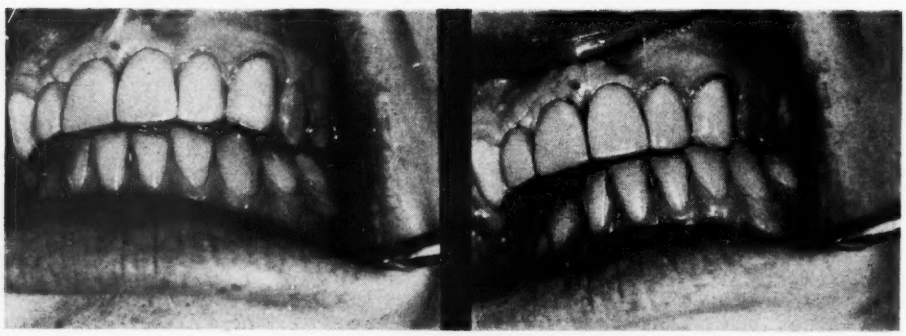


Fig. 19*A*—Atypical wear, the result of a grinding habit. In spite of the marked overjet and freedom in centric contact, the patient wore out the left incisal edge of both the gold and acrylic of the upper left canine. This was done by placing his jaw in the left eccentric position and, with a filing motion, rubbing his teeth together.

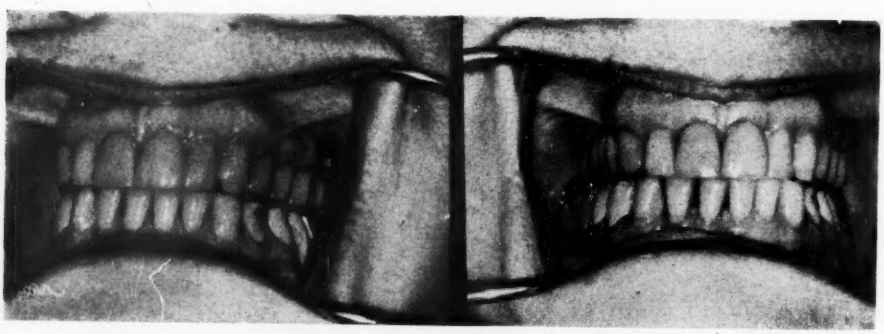


Fig. 19*B*.—Note the marked wear of the lower left bicuspid acrylic-faced crowns. These acrylic-faced crowns were worn to the inner gold crown within one year's time. The patient disregarded the instructions given and vigorously scrubbed her teeth in a horizontal direction.

WEAR OF THE MATERIAL

Since we are here concerned only with the use of methyl methacrylate resins as a labial or buccal veneering material, the question of occlusal wear will not be

discussed. However, the problems of wear because of grinding habits, as well as those of improper tooth brushing, concern us very much.

Tooth grinding habits can cause all dental restorations to wear. When grinding habits are known to exist, regardless of possible effective control measures, protection for the facing should be more emphasized than if no grinding habit existed. To minimize the effects on teeth so affected, all facings on crowns of posterior teeth in the lower jaw should be protected with sufficient metal on the bucco-occlusal aspects of the cusps to prevent acrylic contact when the teeth are in occlusion. As indicated previously, it is this cusp which at all times maintains function. By this additional protection the wear that may occur will be on the gold and not on the more vulnerable acrylic face. Where correct functioning posterior occlusion exists, the wear on anterior teeth is limited; therefore, incisal-edge contact in acrylic can be successfully used in the manner previously outlined.

There are, however, certain situations where unusual tooth grinding habits have been noted. One of these results from placing the lower jaw in a prognathic position and then grinding the upper labial surface of a tooth (Fig. 19*A*). Fortunately, such atypical grinding is rare. More frequently, however, the problem of wear is the result of faulty tooth brushing (Fig. 19*B*).

The individual dentist should make it a point to impress upon the patient that he must follow all instructions as to correct tooth brushing technique. Unless these rules are followed strictly, there is the likelihood that the crown will not give adequate service simply because it will wear out prematurely. If properly applied, the Charter or Stillman tooth brushing methods, or modifications of either, will not do harm to the acrylic. However, since old habits have a tendency to recur, the dentist should further make a point of checking with the patient at frequent intervals to make sure that the new technique is being carried out properly. A more recent development reported by Strock[6] consists of a new brush which may well solve this problem.

In every instance of wear noted, it was found that the patient either ground his teeth perniciously or flagrantly disregarded the simple instructions given him for home care (Figs. 19*A* and 19*B*).

SUMMARY

Because of the adaptability of acrylic material, its application has been vastly broadened, particularly in its use as a processed facing in the anterior cast gold crown.

A method has been outlined to provide adequate and safe retention of the acrylic in the window of a cast gold crown.

New techniques have been offered to assure improved esthetic results by: (1) the use of oxyphosphate of zinc cement powder mixed with acrylic powder as a masking material; (2) the introduction of flash gold-plating hard cast alloys to provide a suitable color reflection background for the translucent acrylic material. Variation of the gold background can supply a range of colors by reproducing a gray, yellow, or red modification of any set of acrylic powders used.

The opaque medium of cement furnishes a guide for the roentgenographic interpretation of acrylic margin in relation to tooth structure.

Technical difficulties inherent in the finishing and cementation procedures have been discussed. The need for understanding and clarifying the vulnerability of this material, in regard to the daily routine of tooth brushing as well as abnormal tooth habits, has been stressed.

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SIX FUNDAMENTAL RULES FOR MAKING FULL DENTURE IMPRESSIONS

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IT was in the year 1891 that G. V. Black advocated a systematic and scientific procedure for cavity preparation in operative dentistry. Today, after more than half a century of the application of these rules, the name of G. V. Black is revered in dental circles the world over. He gave us the divinely inspired instructions which daily assist us to rest assured in mind and comforted in body, knowing that our fillings will be successful when the cavity is made in accordance with these rules.

Let us observe a two-surface cavity involving the mesial and occlusal surfaces of the lower left first molar prepared to receive a gold inlay. Such a cavity, whether executed by a representative dentist of the north, east, south, or west of these United States, a dentist from Johannesburg, South Africa, or one from Barcelona, Spain, would have such uniformity of character as to lead an observer to believe that all the dentists had been taught cavity preparation by one and the same man. In effect they have for, in the passage of time, the rules advocated by Black have been tested and tried by thousands of dentists, and have proved to be so efficacious that their adoption continues to be universal.

Strange but sad is the case of phosthetic dentistry. There is no evidence to indicate that at any time has there ever existed a state of unanimity, at least not for more than a split second, on any phase of that branch of the dental art involving the replacement of the entire natural dentition usually referred to as full denture prosthesis. Today we have a situation in which almost every dentist makes his impression of the alveolar ridges after his own inspiration. He records the functional excursion of the mandible, if at all, by any of a hundred different methods that have been talked about or suggested by an acquaintance. The balance of the work is principally left to someone else to complete—someone whose knowledge in such matters has often been the result of accretion rather than erudition.

To investigate a situation which has existed for such a long time would serve no useful purpose unless it resulted in a determination to try to end this state of confusion, and bring into it a condition of orderliness somewhat akin to the enlightenment that daily sheds its blessing upon the field of operative dentistry, as a result of Black's inspired contribution.

We do not have the revered Dr. Black with us now, but we live in constant hope that the inspiration which guided him in his service to the profession may again be made available to us in this time of our great need.

Read before the joint meeting of the Pacific Coast Society of Prosthodontists and the American Denture Society at San Francisco, October, 1949.

Received for publication, Dec. 8, 1950.

As our first step in procedure must be a determination of what the patient expects, and what the dentist can hope to deliver, the writer has established as the first rule the following premise.

RULE I. RADIOGRAPHICALLY, VISUALLY, AND DIGITALLY EXAMINE THE ORAL CAVITY

Prominent healing institutions are abounding with case histories of patients who have been completely cured of various complaints following the removal from the mouth of cysts, broken roots, unerupted teeth, and portions of fillings which have fallen into open sockets at the time of extraction. These were not known to exist when the patient applied for treatment. In the writer's own experience, a radiograph revealed a fracture of the mandible of only three weeks' standing. The patient suffered a fall and was knocked unconscious, but he was not aware that the jaw had been fractured and had never applied for treatment.

Almost every dentist has suffered the embarrassment of having a lower denture that "never seemed to be comfortable," only to ultimately find an unerupted third molar the cause of the condition. With the modern convenient and compact radiographic equipment available today, there is no longer reason to delay the elimination of these undesirable conditions before any impressions are undertaken.

Visually examine the mouth. Tissue appearance can warn of systemic conditions which would render success without preliminary treatment problematical. Enlarged or pendulous tuberosities will necessitate surgical treatment. Should the mucous membrane present a pathologic appearance which is not a direct result of mechanical irritation, the patient should be instructed to consult his physician and make an effort to correct the condition before proceeding with the case.

The dentist's eye will, no doubt, be attracted immediately should a torus palatinus be present at the suture of the maxillary bones. This abnormality, while frequently encountered, is seldom large enough to necessitate surgical removal.

Observe the maxillary tuberosities. If their form is such that the completed impression cannot be removed and replaced without discomfort to the patient, then surgical correction should be resorted to, until this is possible.

Often the tuberosities are bulbous in form, caused by the retention of an isolated second or third molar tooth, preventing the peripheral border of the completed denture from passing over the prominent buccal protrusion. Removing this protruding part will then allow the periphery of the denture to extend upward to its proper place in the soft areolar tissue, thus perfecting the seal.

It is considered axiomatic that the lower denture, to insure its stability, should cover the entire soft retromolar pad. Accepting this premise, we must then determine that sufficient space is available between the retromolar pad and the tuberosity of the maxilla to permit the presence of the thickness of the denture bases in this area. Should sufficient space not exist, it will be necessary to provide it. This is most frequently accomplished by surgical reduction of the tuberosity which will be found to be cartilaginous tissue, simple to treat and quick to heal.

Examine carefully the bicuspid region of the mandible on the lingual surface to detect the possible presence of bony protuberances (torus mandibularis) which would prevent the successful completion of the denture in this area. These are very simply removed by surgery whenever it is deemed advisable.

The writer discourages the promiscuous surgical treatment of the so-called knife-edge ridge. This should only be resorted to in extreme cases. Ridges, however, which are irregular because of bony protuberances (hyperostosis) should be treated by surgery.

Digital examination will reveal some irregularities not perceptible to the eye. This examination makes the next rule quite evident.

RULE II. SURGICALLY REMOVE SUCH ABNORMAL FORMATIONS AS WOULD PREVENT SUCCESSFUL COMPLETION OF IMPRESSION

Many denture wearers today are dissatisfied with their dentist's efforts because of his failure to properly prepare the mouth prior to making the impressions. It is not wise to create resistence on the part of the patient to any corrective work necessary by painting too vivid a picture of the surgery to be done. It is better to encourage the patient by minimizing the work. For example:

"Mrs. Blank, I am going to have to do a little corrective work in your mouth before taking the impressions." "We do not want to proceed knowing that failure is inevitable, do we?" "Of course not." "The future success and comfort of your dentures depends upon a right beginning, and we are going to see that the foundation for the dentures is in perfect condition." "What am I going to do?" "I am going to correct the condition that has prevented you from enjoying your dentures up to this time," or, "I am going to correct a condition that would preclude your ever wearing dentures satisfactorily." "You will not feel any discomfort when I make the correction, and it will give you greater opportunity for permanent comfort."

Arresting the fears of the patient will make their consent readily obtainable. As it is the policy of many dentists to refer all their surgical operations to the oral surgeon, then in these cases it is only necessary to make a thorough examination and give the oral surgeon detailed instructions as to what is to be done.

RULE III. OBTAIN THE REQUIRED EXTENSION OUTLINE

This rule pertains particularly to the lower impression. In cavity preparation, we are aware that there is an accepted extension outline form. There is an accepted extension outline form for the lower impression, and it is equally as consistent as is the cavity outline form. It is constant and consistent because it is always governed by the same structures, and these structures are in the same position in every case, and they function in the same manner in every case.

This may seem a startling statement. Let us examine it closely. Are the structures always the same, and are they always in the same position? Human beings are identified by their superficial tissues. Strip these tissues off the face, and what do we find? A group of muscles (Fig. 1). Yes, some skulls are a

little larger than others, some a little broader than others, but in the main, all are very much alike.

The tissues pertinent to the prosthetist, as for instance, the masseter muscle will be found in the same place on every head (Fig. 2). It functions in the

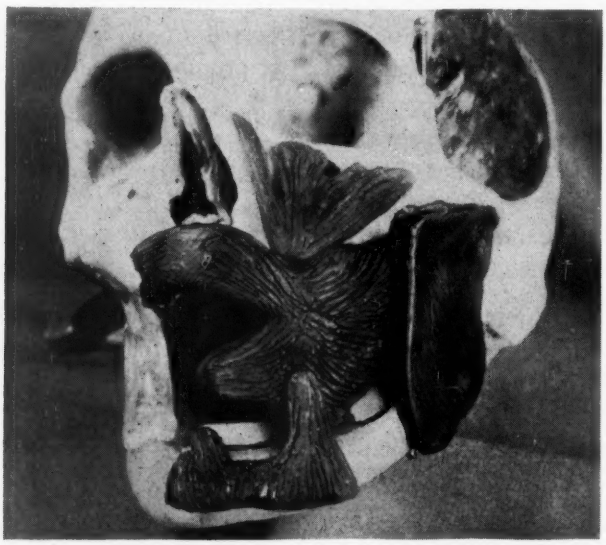

Fig. 1. — The superficial tissues of the face removed would expose the principal muscles of the face in approximately these positions.

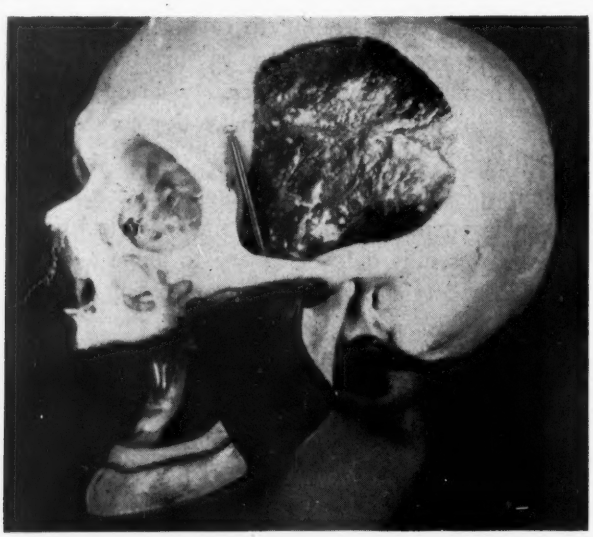

Fig. 2. — The masseter muscle. The retromolar pad is distal to the anterior border of the muscle.

same manner in every head. It does not wander away from its customary origin and attachment even a little bit because its functions necessitate its originating along the inferior border of the zygomatic arch and passing downward and backward and inserting in the external surface of the angle of the mandible.

The anterior border of the masseter muscle will always be found to extend anterior to the soft retromolar pad on the mandible, and consequently will be a determining factor in the distobuccal extension outline of the lower denture. This area so governed has been designated by the writer as the "M" plane ("M" for masseter).

The buccinator or cheek muscle has a maxillary attachment from between the two bicuspids distally to the second molar and an attachment to the mandible in a corresponding location. Anteriorly, its fibers decussate at the angle of the mouth and become continuous with the fibers of the orbicularis oris. Distally, it has a small attachment near the soft pad on the mandible, then passes backward through the pterygomandibular ligament and forms a bond or union with the superior constrictor of the pharynx (Fig. 3).

Fig. 3. — The buccinator muscle. Its fibers run horizontally and decussate with the fibers of the orbicularis oris muscle at the corner of the mouth.

The buccinator or trumpeter muscle forms the body of the cheek. Between the anterior border of the masseter and the distal attachment of the buccinator is an area free of muscle attachment (Fig. 4). This is designated the "B" curve and represents the buccal pouch—an area which permits the extension of the denture base further bucally.

The corresponding position on the ridge marks the location of the molar teeth. That this larger foundation platform should be found available where the greatest stress will be exerted during mastication is much more than a coincidence. It is inevitable and constant because these muscles are constantly in the same positions because of their functional requirements.

The region of the mandible anterior to the buccal pouch or B curve is the principal attachment of the buccinator muscle and is referred to as the "B" plane. This requires a narrowing of the foundation extension buccolingually to permit the free action of the buccinator muscle.

At the angle of the mouth, we note a slightly larger stress-bearing area resulting from the cuspid root area. This has been designated the "C" curve.

From the C curve or cuspid eminence to the medial line is the "I" plane, so called because it is the ridge formed by the loss of the incisor teeth.

The linqual periphery starting at the median line and proceeding distally presents, first, a long plane extending to the second molar region which has been designated the "F" plane ("F" for floor of the mouth).

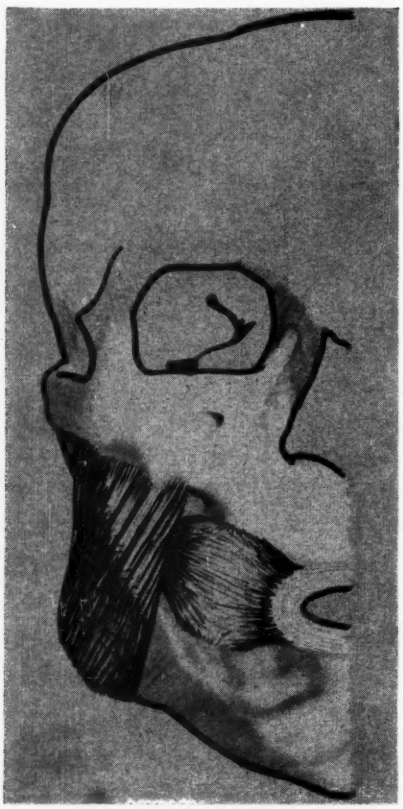

Fig. 4. — Between the distal attachment of the buccinator muscle on the mandible and the anterior border of the masseter muscle is a triangular "free space," the buccal pouch, permitting a large stress-bearing area to the lower base at this point.

The depth of the lingual flange of the impression is governed by the activity of the floor of the mouth. Finally, a curve extends distally then upward from the lingual border at the third molar region (Fig. 5). This has been named the "P-G" curve after the palatoglossus muscle which functions in this area. The palatoglossus muscle passing downward from the soft palate sends a few fibers into the soft pad, then continues on to insert into the side of the tongue.

This constitutes a graphic interpretation of the buccal and lingual aspects of the mandibular denture peripheral outline (Fig. 6). In the writer's opinion

it would be quite in order to make this graphic interpretation an axiom in prosthetic procedure, for as soon as the man in the general practice of dentistry becomes convinced that there are certain structures which govern the outline form of the lower denture, that these structures are constant in position, constant in function, and, therefore, the denture outline form will be constant, the quicker the cloud of mysticism and doubt which has hindered his progress for many years will be dispelled, and he will be given an opportunity to approach the problem of impression making with the same degree of systematic assurance of success with which he approaches the problem of cavity preparation.

To continue to describe the planes from the median line on around the other side of the mouth would simply be a repetition of what has already been stated.

Fig. 5. — The area influenced by the palatoglossus muscle and the floor of the mouth.

As this paper is primarily intended to establish a set of rules for impression making, no further elucidation upon the structures determining the peripheral border of the impression will be attempted; however, it would not be amiss to reiterate the statement previously made that these structures will be found in every mouth, that they will be found in relatively the same positions, and that the resulting outline form can be expected to have a great similarity in all cases. It is, however, necessary that the operator should know the structures governing the outline form, also the positions, or places where these structures will be found, even as it is necessary in the case of cavity preparation to know the outline form to follow in order to prevent recurrence of decay on the surface of a tooth when cutting a cavity. The point to be remembered is that these structures can be expected to be found in the same place, and, therefore, it is possible to retain in one's mind an outline form for a lower denture, or lower impression, and expect all lower impressions to follow it quite closely (Fig. 7).

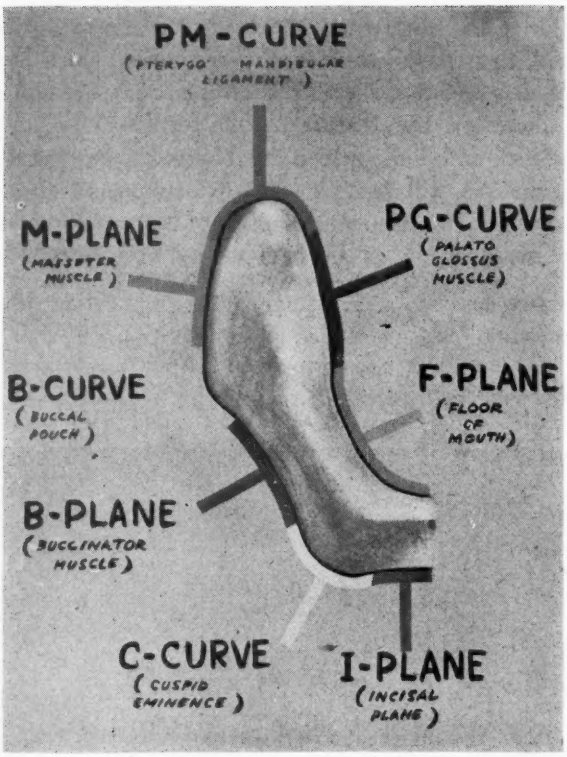

Fig. 6. — A graphic interpretation of the areas influenced by the muscles of the face.

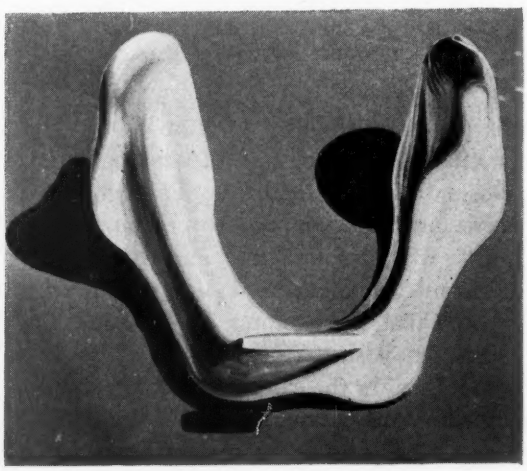

Fig. 7. — An artistic concept of a lower denture base resulting from the action of the various muscles of the face.

RULE IV. LOCATE AND PROVIDE FOR AREAS OF VARIABLE TISSUE DISPLACEABILITY

In considering the area to be included in the maxillary impression we shall find areas in which the tissue displaceability varies greatly.

Let us consider, first, the posterior border of the upper impression area. We often refer to this as the post dam area, because this is where we have difficulty, if at all, in valving our impression or denture in order to secure good retention. At the juncture of the hard and soft palates we find a tissue familiarly designated as deeply yielding tissue. This tissue extending from the hamular notch on one side to the hamular notch on the other side has been charted and designated by various educators according to its variable displaceability. Suffice it to say here, however, that the tissue in this area is of far greater tissue displaceability than any other normal tissue in the maxillary arch. It is possible, in fact advisable, to extend the post dam area of the impression over the proximity of the posterior palatine foramen on either side which will be found approximately one centimeter toward the median line from the position originally occupied by the second molar tooth. This will enable the operator to secure a long valve in the post dam area, rather than the sharp bead which is so frequently resorted to.

The next area to be considered is the median suture of the maxillary bones. In this region it is not uncommon to find the tissue covering the median suture to be very thin. We must provide for relief in this area to prevent the denture from riding on this area when under biting stress.

The next area to be considered is the region of the incisive foramen. Through this foramen emerge the nasopalatine nerve and blood vessels. Pressure must not be exerted on these blood vessels and nerves; therefore, we must provide relief for this area at the time we make our impression.

The remainder of the denture area aside from that which we have considered is covered with resilient tissue. This tissue will accept, without complaint, the responsibility of the biting stresses under which the denture will constantly be placed, providing these stresses are equalized by proper occlusion.

We have considered the normal mouth. In the case of abnormalities such as pendulous tissue which probably would occur in the anterior or incisal region, also such conditions as a torus palatinus, or any other areas which are not ordinarily encountered, these areas should be considered individually and provision made for them in the impression.

RULE V. OBTAIN THE REQUIRED RETENTION OUTLINE

The question of the retention of the dentures is not only of interest to the patient, but also a great satisfaction to the dentist. There is now and, no doubt, there will continue to be constant disagreement and discussion as to where the periphery of a denture should extend. Some educators teach that it should be free from any muscle attachments, while others insist upon extending the periphery on to the soft areolar or placeable tissue. It is not the writer's intention that this paper should deal with theories, but rather with facts; therefore, in the answer to this question I shall attempt to keep the statements factual.

All have, at some time or other, had occasion to use a rubber suction cup, and possibly to moisten this suction cup and press it against a window. In expressing the air from inside the suction cup and sealing the periphery of the suction cup with moisture to the glass, a perfect seal is accomplished, and the suction cup is retained firmly to the glass. This type of retention has been tried in the mouth in years gone by and proved to be intolerable to the tissues. We do find the mucobuccal fold, or the mucous membrane of the mouth at the point where it leaves its attachment to the alveolar process and becomes the lining of the mouth, will tolerate some impingement of the periphery of the denture without registering complaint. By carrying the periphery of the denture into this yielding tissue, the seal is obtained which prevents the easy ingress of air or moisture underneath the denture and prevents its easy dislodgment. Without conscious effort our maxillary dentures are all sealed or valved in this manner. To complete this valve we increase the pressure across the posterior border, or as we say, we post dam the denture. This actually completes the peripheral seal of the maxillary denture and aids in its retention. This is also possible in the mandibular denture by sealing the periphery into the soft yielding tissue in exactly the same manner as we are accustomed to sealing the maxillary denture.

RULE VI. OBTAIN THE REQUIRED ADAPTATION

It is generally accepted that adhesion is the principal factor in the retention of a denture. Webster tells us that adhesion is the molecular attraction exerted between the surfaces of bodies in contact. This attraction is greater as the surfaces of the bodies are closer together. In dentistry we have the denture surface in contact with the tissues of the ridge with saliva in between. The closer the adaptation of the surface of our denture to the surface of the ridge, the greater will be the adhesion. The final treatment of our impression, then, should be to complete the adaptation of the surface of our impression material to the surface of the ridge with as great an accuracy as is possible. This can be accomplished in many ways. Some operators are skillful enough with modeling compound to secure the necessary adaptation. Others do not feel that they are so qualified and find it necessary to use some of the zinc oxide-eugenol pastes which are on the market today. Still others like to use thin washes of plaster of Paris. The manner in which this is accomplished is quite immaterial as long as the foundation of the impression which has previously been established by the muscle action is not disturbed and the tissues to be recorded are not displaced by pressure.

It is believed that the close adherence to the foregoing rules will prevent many failures in impression making, and insure greater satisfaction in the finished dentures.

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THE TRANSITION FROM NATURAL TO PROSTHETIC DENTURES

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THE practice of providing our patients with prosthetic dentures immediately following the removal of the last remaining natural teeth is no longer a novelty. It is now routine procedure in most dental offices. It is no longer regarded as a special service limited to certain carefully selected cases. The practice has many well-recognized advantages and to mention them all would involve unnecessary repetition. Suffice it to say that the elimination of the completely edentulous period provides the patient with a certain degree of continued masticatory efficiency, in addition to the equally important psychologic benefits and assistance in becoming accustomed to the secondary denture. Except for the few contraindications noted below, this service is recommended for all patients for whom the transition from natural to prosthetic dentures is indicated.

CONTRAINDICATIONS

These three general contraindications will eliminate a comparatively small percentage of patients from the immediate denture program.

1. This service is not recommended for patients who display an uncooperative or antagonistic mental attitude since an appreciative and cooperative patient is necessary for any really successful prosthetic service and since immediate prosthetic replacements involve certain discomforts.

2. Certain cases of weak, nervous, or debilitated patients where the surgery incidental to the removal of several teeth at a single appointment seems inadvisable.

3. Cases of extreme malrelation of the jaws, excessive overbite, or the loss of several anterior teeth leaving an undesirable pattern for restoration.

OBJECTIVES

In the transition from natural to prosthetic dentures the over-all objective is the removal of the remaining natural teeth, the elimination of local pathologic conditions, and the provision of a comfortable, well-functioning prosthetic substitute of pleasing appearance. It is equally important that the restoration be designed in such a fashion that it will provide maximum preservation of the denture-

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supporting area. It must be recognized that the immediate or primary denture is but the first step toward attainment of the desired results. It is important that the patient understand the nature of the successive changes occurring in the tissues and that these changes limit the duration and effectiveness of the primary denture. It is well recognized that the stability of the dentures and the preservation of the supporting tissues are dependent upon an occlusion which is in harmony with jaw relations and positions. Since the duration and effectiveness of an established occlusal harmony are dependent upon the stability of the supporting tissues, any change which occurs in the tissues after placing the restoration must necessarily contribute to an occlusal disharmony. Tissue changes rapidly follow the surgical procedures incidental to the placing of an immediate denture. For this reason, efforts in making mandibular excursion records are at least partially neutralized very shortly following the placing of the restoration. The progress and extent of these changes vary greatly with different cases dependent upon such factors as: type of osseous structure, number of teeth removed, age and physical condition of the patient, and the condition of the periodontal structures. In view of these factors, we follow a somewhat different procedure in the construction of an immediate denture from that used in patients who have been edentulous for some time. I am referring especially to jaw relation records and type of posterior prosthetic teeth. In many of these cases we omit the eccentric registration record and select mechanical posterior teeth. Again we must be influenced by our judgment regarding the stability of the denture-supporting tissues.

PROCEDURE

For the purpose of description we will divide the procedure involved in immediate denture service into five phases: diagnosis and prognosis, impression making, jaw relation records, selection and arrangement of the prosthetic teeth, and surgery and delivery of the dentures. Of course, the last phase must include postdelivery adjustments, maintenance, and periodic examination in preparation of the building of the secondary or so-called "permanent" restoration.

DIAGNOSIS AND PROGNOSIS

It is difficult, if not impossible, to overestimate the importance of this part of our work. Be sure the patient understands the objectives, possibilities, and limitations of the case. X-ray examination will aid in determining the extent of the surgery required, the type of osseous structure, and the probable pattern and rate of resorption. Study models are helpful in the diagnosis of occlusal disharmonies and alignment, and they are a very valuable aid in the selection, modification, and arrangement of the prosthetic teeth. They also serve as a permanent record for reference when supplying the secondary dentures.

The mental attitude of the patient is very important and in many cases will be the deciding factor between success and failure. We must emphasize the necessity of cooperation. Many patients expect their primary dentures to be permanent and will cite instances of their friends or relatives who have been wearing

their "first dentures" for many years. Practically every primary denture which has been in service for a year or longer should be replaced. In many cases this should be done within a few weeks or months. Resorption is always accompanied by maladaptation and malocclusion and there is always some resorption following the placing of the primary denture. Resorption is an inevitable sequence, regardless of the extent of the surgery or the skill of the surgeon or prosthodontist.

Patients display a great variation in mouth tissue tolerance of prosthetic dentures. There is no accurate means for determining the degree of tissue tolerance. I think it may be said that patients who have diabetes, lowered vitality, circulatory disorders, or certain other conditions are very likely to present a low degree of tissue tolerance.

Time spent in diagnosis and prognosis is time well spent. I have said and I repeat that the average dentist spends more time in postdelivery adjustments and explanations than he spends in the actual building of dentures. Remember that there are no two patients alike in all the factors and conditions with which we have to deal. Each case presents its own special problems.

IMPRESSIONS

Before making the impressions for immediate dentures, all posterior teeth should have been extracted for a period of from thirty to ninety days, the length of this period depending upon the number of teeth involved and the condition of the supporting structures. Since there is usually little or no readily displaceable tissue in immediate denture cases, little variation in impression technique is required.

We use one of the alignates for making preliminary impressions from which casts are run in plaster of Paris.' Shellac baseplates are adapted to these casts to form trays for our final impressions. The trays should cover the denture-supporting area to within about one-sixteenth of an inch lingual to the remaining anterior teeth, and should not include any of the area to be involved in the surgery. The trays are reinforced with a thin layer of modeling compound. Final adjustment should be made after trying the trays in the mouth.

The tray is loaded with a zinc oxide-eugenol impression paste and seated in the mouth with a minimum of pressure. The partial impression is now removed and corrected until it is satisfactory. The partial impression should possess completed borders. Then it is reseated. The operation is completed by loading a perforated tray with an alginate impression material, and completely covering the previously seated partial impression and the anterior tooth area. Any of the alginate material which extends buccal to the borders should be trimmed off.

We now have a final impression with the edentulous areas completed in the zinc oxide-eugenol paste, and the anterior area in alginate. This type of impression is superior to one made entirely with the alginate material in that is possesses more accurate borders and, as it is less bulky, has less tendency to cause distortions in the posterior palatal area.

JAW RELATIONS

Casts are poured in artificial stone. Wax occlusion rims are adapted and a centric relation record is made by interposing equalizing wax between the occlusion rims, and having the patient close in centric relation. The remaining teeth are helpful in securing an accurate jaw relation record. Some of these cases require some increase in vertical dimension. This is especially true in cases presenting marked periodontal disorders, or premature loss of several posterior teeth without prosthetic replacement. Many times the remaining anterior teeth will have a tendency to protrude in the interval between the removal of the posterior teeth and the construction of the artificial denture. Of course this movement of the anterior teeth is accompanied by a loss of vertical dimension when the teeth are in occlusion. The vertical dimension is determined by establishing the rest position of the mandible and a normal free-way space.

The casts are mounted in an anatomic articulator and the condylar inclinations adjusted to +30 degrees.

SELECTION AND ARRANGEMENT OF PROSTHETIC TEETH

Anterior teeth are selected and positioned. An effort is made to imitate the shade, form, and arrangement of the patient's natural teeth. We are using an increasing number of the new plastic teeth with pleasing results. They lend themselves well to "artistic irregularities" in arrangement and color. Marked irregularities of color and arrangement are duplicated or modified according to a pattern agreed upon during consultation with the patient. A little time spent in discussing this important step with the patient is time well spent.

"Esthetics in prosthetic denture construction" is a much discussed subject. Progress in this field is as much a result of the efforts of the manufacturers of prosthetic teeth and denture base materials as of the work of the dentists. We should make the most of the materials available for this work.

Mechanical or cuspless posterior teeth are quite satisfactory for most immediate replacements. It must be admitted that the flat occlusal surfaces of the mechanical tooth forms are a compromise with masticatory efficiency, yet I believe they are justified in immediate denture cases or in any case where the denture-supporting area suggests a probability of marked instability of form. As previously indicated, the immediate denture is a treatment procedure and there is no possibility of maintaining a harmonious occlusion with the anatomic tooth forms throughout the period of extensive tissue change. We must be guided by our judgment regarding the probable nature and extent of those changes.

Before beginning the arrangement of the teeth, the cast is trimmed in accordance with the proposed surgery. It is definitely the responsibility of the prosthodontist to prescribe the pattern and the extent of the surgery. The trimmed cast should represent a pattern for the preparation of the tissues and the trimming should be done with certain objectives in mind, chief of which is the removal of the remaining anterior teeth with sufficient labial alveolar bone to permit the placing of a denture with a labial flange and at the same time avoid a displeasing lip contour.

We should attempt to visualize the contour of the alveolar ridge as it would appear after about three months of resorption following the removal of the teeth, and prepare the cast accordingly. As previously mentioned, the rate and extent of resorption will vary according to conditions.

SURGERY

We should avoid radical surgery. I have seen many satisfactory immediate denture cases in which the surgery was confined to the removal of the remaining teeth and a slight smoothing of the process.

In the average case we should remove labial tissue in volume proportional to that involved in the prosthetic replacement. It is neither necessary nor advisable to remove bone in the amount necessary to permit the placing of a labial flange with thick peripheral border comparable to that used in the secondary denture. I like to use a thin labial flange even if it has a tendency to thin out to a comparatively sharp peripheral border. No matter how radical the surgery may be, it will always be followed by resorption. There is no possibility of producing a permanent alveolar ridge contour by means of surgery.

The skill and ability necessary for the surgical preparation of the mouth for immediate denture restorations is quite within the limits of that possessed by the average general practitioner of dentistry, and if the tissues are prepared by the prosthodontist, it makes for a broader distribution of this type of service. Following the preparation of the tissues, the dentures are fitted, gross disharmonies in occlusion and borders are corrected, and the patient is dismissed for twenty-four hours with instructions to follow a soft diet and not to remove the dentures until we see him the following day. Indicated adjustments are made as often thereafter as seems necessary.

THE SECONDARY DENTURE

The primary denture should be worn until the supporting tissues are somewhat stabilized by resorption. This period will range from a few weeks to a year or more, varying with local and systemic tissue conditions. It is impossible to predict accurately the duration of the effectiveness of these primary restorations. They should be examined at regular intervals, and the patient should understand the necessity for a new denture when indicated in order to preserve desirable ridge form as well as masticatory function. Some dentists instruct their patients to wear the primary dentures as long as they are tolerable. This may cause irreparable damage.

It is not within the scope of this short essay to discuss the technique involved in supplying the secondary denture, except to say that it is my belief that a completely new restoration should be made rather than attempt to correct the primary denture. In support of this contention the following reasons are offered:

1. The patient is not deprived of his dentures, even for a day.
2. Due to limited denture space, it is often necessary to grind the occlusal surfaces and shorten the teeth which are placed on immediate dentures, making them unsuitable for the secondary restoration.

3. It is difficult to avoid tissue displacement in the impression procedures commonly followed in relining or rebasing immediate dentures.

4. Due to the more stabilized form of the denture-supporting tissues following a few months of resorption, we are better enabled to make functional and positional jaw relation records, and to utilize them in effecting a harmonious occlusion with efficient, anatomic posterior tooth forms.

5. It is often necessary to make some alteration in the positional relation between the teeth and the alveolar ridge in order to eliminate leverages which interfere with retention and stability.

CONCLUSIONS

Immediate replacement should be a routine procedure in cases where the transition from natural to prosthetic dentures is indicated. A simple technique is indicated for supplying the immediate denture. Involved procedures and complicated and expensive articulators do not produce results which justify their use.

The surgical procedure should be as simple and uncomplicated as possible. It should be limited to the removal of the remaining teeth, and whatever tissue is necessary in order to eliminate pathology, and to permit the placing of a restoration of pleasing appearance. This does not require the services of a specialist in oral surgery. Every dentist should be a specialist in the prevention and elimination of dental pathology, and the correction of abnormalities of the teeth and associated structures. It is the responsibility of our profession to make this service available to an increasingly dentistry-conscious population. If we are not mindful, dentistry will lose its meaning and identity in a maze of subspecialties.

It should be remembered that the most important factor in connection with immediate denture work or any prosthetic treatment is careful diagnosis and prognosis.

Everything possible should be done to obtain and keep the confidence and cooperation of the patient. Avoid disappointments and misunderstandings. Some of the greatest thrills I have experienced in the practice of dentistry have been produced by my being able to share with my patients the pleasures and delights which are the result of a successful immediate denture replacement. I have seen many instances in which there seemed to be a complete rehabilitation of a somewhat shattered morale. Of course, all cases will not terminate to the satisfaction of the patients but, with careful attention to fundamental details, the percentage is definitely in our favor. If we have given the best possible treatment of conditions as they existed, then our work may be regarded as successful. Certainly this work will contribute to the making of happier and healthier patients who will have a greater appreciation of dentistry as a health service.

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PREPARATION OF THE MOUTH FOR IMMEDIATE DENTURES

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Any operation, whether it be in the field of medicine or dentistry, should be designed to benefit the patient, and should be performed only in the presence of conditions that require correction. The object of any surgical procedure within the mouth should be the elimination of abnormal or pathologic conditions. Because surgery of this type frequently involves the loss of teeth, with consequent impaired function, careful consideration must be given to the physical, mechanical, and esthetic results. The construction of artificial dentures on a base as near to normal as it is possible to obtain necessarily becomes an important part of such a procedure.

Many of the unsatisfactory results following surgical preparation of the mouth for dentures have been due to lack of understanding of the demands and limitations of the prosthetic service by the one who has removed the teeth. Likewise, the dentist who is to restore the mouth has failed to recognize the surgical problem and has refrained from referring the patient for such service in fear that radical surgery will be performed. Cooperation between the oral surgeon and the prosthodontist, or a thorough knowledge of the problems of each, is, therefore, imperative if the best results and increased benefit to the patient are to be our objectives.

The first step preceding any surgical procedure in the oral cavity is a complete dental radiographic examination. Radiographs of edentulous areas are as important as those of areas in which there are teeth, in that retained root particles, unerupted teeth, cysts, and residual areas of infection are discovered in many instances where clinical examination has been negative.

Patients may unintentionally withhold the information that they are under medical care, feeling that any surgical procedure associated with the teeth is minor in nature. A brief history with a few well-directed questions will usually suffice to bring out what we want to know about the patient's general condition. Full cooperation of both physician and dentist should be given a patient under medical care in order to ensure the best possible service and protection to both patient and dentist.

After having examined the mouth carefully with the dental radiographs and determining that immediate dentures are indicated, a definite operative schedule can be set up. Appointments may be given for operative sessions for removal of the posterior teeth at intervals compatible with the patient's age, general condition, or the presence of infection, as it is these factors that determine the number of teeth that can be removed safely at one time.

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The selection of an anesthetic rests with the dentist and not the patient. General anesthesia is indicated, with few exceptions, in cases of marked apprehension, true sensitivity to procaine, and acute infectious conditions in which blocking with local anesthetic agents would not be satisfactory. If the office is equipped to cope with any emergency that may arise and if the anesthetist is well trained, there is no objection to the use of general anesthesia providing the operator obtains a good surgical result.

The differentiation between so-called minor and major oral surgery is difficult, for the extraction of a tooth, which is considered a minor procedure, may become major in every sense through complications. When surgery is indicated in the presence of acute or subacute infection, the sulfonamides or preferably penicillin can be given preoperatively in order to aid in prevention of the spread of infection either during or following operation.

To aid the nervous, apprehensive patient, 1.5 to 3 grains of one of the shorter acting barbiturates, or from 50 to 100 mg. of Demerol hydrochloride given preoperatively, will reduce nervous tension to the extent that the operation can be successfully performed without the patient experiencing any generalized upset such as palpitation, profuse perspiration, and even syncope.

It is a well-established fact, recognized by leaders in the prosthetic field, that in the removal of all teeth an operative technique should be employed which will facilitate the insertion of dentures upon a base free from rough, jagged margins of bone that are too often left for nature to smooth following extraction. The desire for this result is to be found in dental literature of many years ago, when reports show the use of extracting forceps for the reduction of sharp spicules of bone.

The removal of a tooth is a surgical procedure, requiring the same surgical principles as are followed elsewhere in the body. It is the operator's obligation to remove all teeth with the least amount of trauma, to eradicate pathologic areas associated with the teeth, and to remember that he is preparing the foundation upon which the patient will necessarily wear a restoration.

The amount of surgical interference in the preparation of the mouth for full denture reception may be determined by six important factors:

1. *Pathologic conditions,* such as are revealed by radiographs, clinical examination, and history. All pathology should be necessarily eliminated at the time the teeth are removed.

2. *Esthetics,* whereby the reduction of the labial and buccal alveolar bone will permit the proper alignment of the artificial teeth so as to restore normal facial contour and prevent undue fullness of the lips or exposure of an excessive amount of denture material with changing facial expression.

3. *Mechanical reasons,* such as the reduction of large bony protuberances, excessively heavy alveolar crests, large bulky tuberosities, or sharp prominent mylohyoid ridges, which may interfere with securing an accurate impression or the proper seating of the denture.

4. *Ridge relation,* or the relation of the maxillary and mandibular alveolar ridges to each other. Where there is malrelationship between the upper and

lower jaws, surgical correction will often assist in harmonizing the ridges and permit a more ideal articulation of the artificial teeth. Abnormal opening of the vertical dimension due to lack of space for denture material and teeth may also be prevented by proper mouth preparation.

5. *Abnormal muscle or frenum attachments.* Surgery of the soft tissue is as often necessary as the reduction of the osseous structures. Frequently muscle and frenum attachments must be modified in order to permit better retention of the denture as well as normal facial expression.

6. *Soft flabby ridges.* A condition resulting from excessive hypertrophy of the mucosa and submucosa or atrophic changes in the alveolar ridge, which if not corrected surgically will seriously affect the stability and efficiency of the full denture.

All these factors being duly considered, the necessary surgery is performed in accordance with the requirements of the individual case. In some patients the teeth may be removed before incision is made or the soft tissues reflected from the labial or buccal surfaces. In other instances it is advantageous to make an incision about the necks of the teeth and over the crest of the alveolar ridge sufficiently far to permit the reflection of a mucoperiosteal flap. Such a procedure affords a clear view of the osseous structure and protects the soft tissues from injury during operation.

In patients in whom difficult extraction is anticipated due to a heavy dense alveolar process, hypercementosed or curved roots, the removal of a portion of the labial or buccal plate of alveolar bone is indicated. This facilitates the removal of teeth in that it prevents fracture of large fragments of buccal or labial plate as well as the fracture of teeth. Where destruction of bone has been excessive, as in cases of extensive pyorrhetic involvement, the removal of the teeth and pathologic tissues and the smoothing of sharp jagged margins of alveolar bone is all that is usually necessary.

Following the removal of the teeth the alveolar process in the anterior portion of the mouth is reduced by arcing the labiolingual contour from a point corresponding to the "high lip line" to the palatal or lingual margin. The high lip line is determined before operation by having the patient elevate or slide the lip upward over the teeth and gingival tissues as far as possible by the muscle action of the lip itself. This form of preparation will prevent occurrence of the high thin ridge, which has been the object of so much criticism following attempts to reproduce the so-called "V-shaped" ridge.

In the posterior areas reduction of rough sharp margins of alveolar bone, large bony protuberances, bulky tuberosities, and prominent mylohyoid ridges is indicated. The contour of the posterior ridge is prepared by arcing from buccal to lingual, similar to that of the anterior portion. Reduction of these areas should be made from a point midway between the greatest depth of the vestibule of the mouth and a line corresponding to the high lip line. Such a preparation will again result in a rounded arched alveolar ridge which will present the greatest surface at right angles to the long axis of the artificial teeth in the primary stress-bearing area.

After preparation of the osseous structure the next step is the trimming of the mucoperiosteal flaps. Frequently there is a thick fibrous tissue pad overlying the tuberosities which, if not removed, interferes with the proper articulation of the artificial teeth. The same is true in the retromolar fossa of the mandible. These areas may be reduced by excising a V- or wedge-shaped section of tissue, undermining the flaps, and closing them with sutures. Trimming of the soft tissues is equally important in the anterior portion of the mouth, especially where there has been rather extensive reduction of alveolar bone. Sufficient gingival tissues should be excised from the margins of the flaps so that when they are approximated over the crest of the alveolar ridge there will be no folding or puckering. If this is not done the final result may be a flabby mobile ridge which seriously interferes with the stability of the denture. Emphasis should also be placed upon the complete excision of all infected granulomatous tissue.

The number or type of sutures necessary to reapproximate the mucoperiosteum varies, with some cases requiring more than others to obtain a properly prepared ridge. Great care must be taken in the placing of sutures to prevent a change in the depth of the mucobuccal fold by attempting to actually close the tissue flaps. Occasionally, mouth preparation has been criticized as having resulted in the removal of an excessive amount of alveolar bone when, as a matter of fact, the mucobuccal fold has been altered by improper suturing. The immediate denture, of course, acts as a splint and aids in holding the soft tissues in their proper relationship.

The labial frenum or the other facial muscle attachments may encroach upon the crest of the alveolar ridge and seriously interfere with denture retention. They may be eliminated by a Z-plastic operation or by complete excision followed by undermining and closure of the adjacent soft tissues. Again the immediate denture aids by splinting the tissues in proper position.

Following operation and insertion of the denture, the patient should be instructed in home care. He should be warned to expect swelling and possibly ecchymosis. Moist heat applied to the outside of the face over the operative site usually is beneficial in the control of postoperative pain, while ice should be employed to combat swelling. Instructions regarding a high caloric, high vitamin, liquid or semisoft diet as well as careful attention to elimination are indicated.

Analgesic medication frequently prescribed is Empirin compound with 0.5 grain of codein, 50 to 100 mg. of Demerol hydrochloride, or from 5 to 10 mg. of methadon hydrochloride, the latter two being synthetic analgesics, also with addiction potentialities. Any one of these medicaments may be repeated every four hours, if necessary, for the relief of pain.

After forty-eight hours the sutures can be removed, and the mouth irrigated and cleansed with a bland mouthwash diluted with warm water. The patient is observed at regular intervals until healing has reached the point that we are certain no complication will arise.

SUMMARY

The following points are important and should be emphasized:

1. Complete oral diagnosis pertaining to physical, mechanical, and esthetic results.

2. A predetermined plan of procedure for both surgical and restorative service.

3. The importance of recognizing conditions requiring surgical interference:

   A. Pathologic

   B. Esthetic

   C. Mechanical

   D. Ridge relation

   E. Abnormal muscle attachments

   F. Soft flabby ridges

4. A technique as a basis of operation to insure a properly prepared mouth with well-rounded arched alveolar ridges which will present as much surface at right angles to the long axis of the artificial tooth as it is possible to obtain.

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FACIAL TEMPLATES AND STABILIZED BASEPLATES WITH THE NEW CHEMICAL SET RESINS

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IT is seldom possible to render to patients an unusual and beneficial service which they can readily understand and appreciate. They have too long associated dentistry with tooth carpentry. It has been particularly gratifying to find some of the new resins being used as new tools to demonstrate some of the technical value of our work as well as the fact that there is "romance in dentistry."

The truth and scope of this romance impresses me every time I meet, in convention, with our men of vision whose research and sincere belief in our profession and its worth are an inspiration to us all. Each time I delve into dental literature I am convinced all over again of its great work and great value. Reading the reports on obtaining centric relation and vertical dimension by such men as Gysi, Walker, House, Hanau, Swenson, LaDue, Gillis, Tench, and others has been informative, with each man opening a door for us to seek further truths.

I am in agreement with Washburn who in 1926 said: "There is now a realization that no one person can in a lifetime solve dental problems and produce a device for replacing all types of lost tooth areas."[1]

The information I wish to impart is merely an elaboration of a practical method for using a new tool which was given us by the commercial manufacturers of plastics. It can aid us in determining vertical and centric relation, and in our try-ins in denture work. This tool has proved of great value in my office as I hope it will in others.

Cole and Twible of Toronto[2] list well-adapted bases, correct vertical dimension and correct centric relation as the first three requirements in denture construction. Other writers concur in that opinion. Volumes are written on how to obtain the correct vertical dimension with the use of everything from photographs and esthetics to mechanical measurements. There is not much written on how to construct a well-adapted base, although everything from compound to sandarac is mentioned.

THE FACIAL TEMPLATE

Many of our good men have used and advocated face masks and templates, prepared before extractions whenever possible, as a means for determining vertical dimension. This has been a clumsy procedure in the past, and almost prohibitive when the impression materials were limited to plaster of Paris and

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waxes. The use of hydrocolloids opened the first door to a new technique, but there still remained the problem of the construction of the template. The processing of one in clear acrylic required a procedure which was too long and complicated to be practical.

The advent of the new chemical set, or self-curing resins (as they are called interchangeably) has opened a second door, within the past two years. Face masks with almost transparent facial templates are now made with a simple procedure. We can also discard our old methods for making baseplates and put onto the list of outmoded dental tools the shellac bases with their zinc oxide and eugenol lining, or vulcanite and acrylic bases with their involved processing.

Obtaining vertical dimension in an already edentulous mouth is not the subject of this report, but rather the determination and recording of this dimension before extractions take place. We can now determine and record these measurements by a method that can be preserved for permanent record.

The procedure for taking a hydrocolloid impression of the face is simple. Heating in a double boiler will reduce the hydrocolloid material to a liquid state in about 45 minutes, during which time it may be necessary to add more water to the material. It is then chilled to about 125°F. before using. It is not necessary to prepare the face in any way. Simply protect the surrounding area from dripping material by placing a dental bib close to the neck. The patient should be told that the feeling of warmth when the material is first applied will not result in a burn. The hydrocolloid can be painted on the face with a brush and spatula. A light stream of air may be directed at any spot that flows too rapidly. The patient's head should be in a very slight reclining position with the teeth at rest *(not closed)*. The flares of the nostrils should be carefully painted to avoid covering the opening. The material should be carried to within an inch or so of the lower eyelids as only the lower two-thirds of the face is needed for the record.

Many methods are suggested for holding the hydrocolloid in shape and position. A thin layer of plaster of Paris may be used, or a baseball mask, or an outline of one-eighth inch copper wire previously prepared to approximate the facial shape. (The wire can also be used to force cold water over the area as in other hydrocolloid impression trays.[2]) The easiest procedure for the operator to use should be selected.

The facial impression may be taken by the assistant in the absence of the dentist, if desired, since it does not involve operations in the oral cavity.

The hydrocolloid impression can be treated with the fixing solution by filling it with Kleenex or paper towels saturated with the solution. The stone cast is poured, rolling the soft stone around in the impression like a wash at the start. The cast should be allowed to set thoroughly before it is separated.

Use one thickness of baseplate wax to outline the form of the finished template. Leave a sprue of wax at the top of the nose area and connect a sprue below the chin line, and at the outside edge of each cheek area. All sprues should connect at the top of the nose area. A bulk of plaster of Paris (laboratory plaster) is poured over the pink wax to form the second half of the mold, (the facial cast forms the first half of the mold,) leaving only the sprue hole open.

When the plaster has set, the halves of the mold are separated, the wax removed, and the mold cleaned thoroughly with boiling water. Then the mold is painted with one of the alginate separators and both halves of the mold are carefully tin-foiled. Petrolatum will act as an adhesive for the tin foil. The mold is then reassembled and a new mix of plaster used to seal the two parts together except at the sprue hole which must be left open. No further flasking is necessary.

The casting resin (as it is commercially called) is mixed according to the directions of the manufacturer and poured into the upright mold as a liquid when it begins to thicken. At this time it will have taken on an amber color. When the mold is filled to the top of the sprue hole, no further attention is necessary. The case may be set aside to be separated the following day. The tin foil is then removed, the edges buffed, and the nasal openings made. No polishing is necessary in the body of the template. It will be amber in color but sufficiently transparent to determine the nose-to-chin relationship when returned to the face.

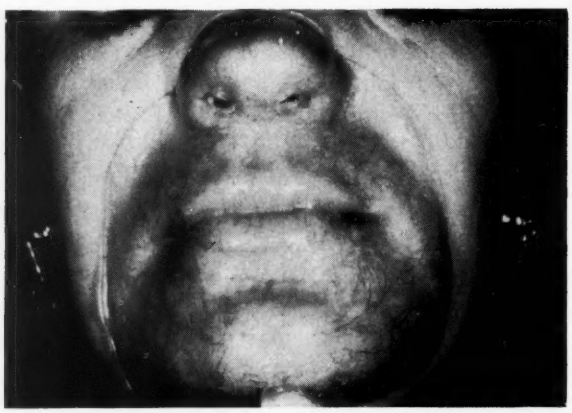

Fig. 1. — Facial template in place after extractions were completed and dentures inserted.

The stone cast may be given to the patient and the template kept in the dental office. Each patient will have room for one cast at home, and the template is small enough to be kept as an office record. This method may be followed routinely for every patient whose oral health indicates future placement of dentures. Patients not only are interested in the procedure but grasp quickly the value and usefulness of the template. They generally indicate that dentistry has risen a step in their estimation. (Figs. 1 and 2.)

THE INDIVIDUAL TRAY

For the individual tray, the stone or plaster cast made from the primary impression is allowed to set and is wiped with petrolatum. A sheet of pink wax is adapted to the area of the impression, after the undercuts are waxed out, and a mix of the chemical-set resin prepared. When approximately one minute has elapsed and the plastic bulk takes on "body," it is rolled out as pie dough into an aluminum pattern which will create the same shape as the prepared shellac bases. A bottle can be used as a very successful "rolling-pin."

The sheet of plastic is then laid over the wax-covered cast and adapted quickly with the fingers. Dampened cotton rolls will help hold the distal ends of a lower tray. A small piece of excess material, to be used for making a handle, is flattened with the fingers and laid aside along with the cast until the material has set. In 10 or 15 minutes the tray may be removed, trimmed around the edges, and the handle attached to the tray by wetting it with the liquid on one end and pressing it to the proper place on the tray. The time involved in the construction of the tray is so negligible that every impression may be made in an individual tray.

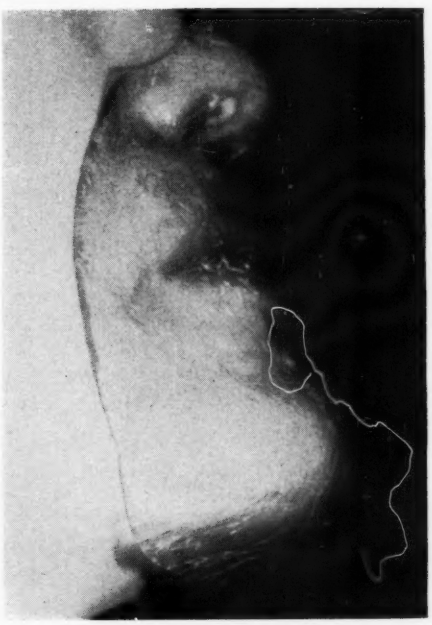

Fig. 2. — Facial template in place showing collapse that had occurred in four months' time.

THE STABILIZED BASEPLATE

The finished impression can be taken with the material of choice and the working cast poured in stone and allowed to set. Undercuts in the cast should be waxed out preparatory to making the baseplate. One thickness of pink wax is adapted over the cast, and an impression is taken of the whole with an oversized tray filled with used modeling compound. When the compound has set and been removed, it is tin-foiled rather carefully after using petrolatum on the impression surface. The wax is removed from the cast and the cast coated with petrolatum. The resin dough is prepared the same as for the individual tray. The dough is again rolled into a sheet, adapted to the cast and the modeling compound-matrix tray is forced over it.

The baseplate is ready for use in 15 minutes. If the pink wax has been carefully outlined the only finishing necessary will be the removal of the flash at the periphery. The petrolatum on the cast and the foil on the matrix will have left a gloss, so no polishing is necessary.

The stabilized baseplate is then ready to receive the wax for the occlusion rim, or the mechanical unit for determining centric, or the teeth for try-in; it will feel sufficiently comfortable in the patient's mouth as to make it easier to obtain registrations. We are all aware of the need for having a relaxed patient when determining centric. The minimized bulk and security of fit of these baseplates will go a long way in reassuring patients and conditioning them for their dentures. They are no longer afraid that the wobbly base is an approximation of the finished product.

The best results will be obtained if the baseplates are kept moist by covering the articulator with a damp towel when they are not in use.

Those who process their own dentures will find an additional short cut in the waxing, as the proper thickness will already have been determined by the tray without further waxing and trimming. The bases fit so securely on the cast that there is no chance of an alteration of tooth positioning in the transfer from mouth to articulator.

Thus we have new tools with which to work, as the romance and adventure of dentistry continues to unfold. They will help us to a greater accuracy together with more simplified, rather than more complicated techniques.

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ACRYLIC DENTURE BASE MATERIALS: THEIR PHYSICAL PROPERTIES AND MANIPULATION

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THE acrylic resins, particularly polymethyl methacrylate, are peculiarly adapted to the needs of dentistry, particularly for the fabrication of denture bases, both complete and partial. The remarkable clarity of a methyl methacrylate resin, its relatively high strength and hardness, its color stability under all conditions of dental use, its insolubility in the mouth fluids—all of these properties combine to provide an excellent material for the prosthetist.

Polymethyl methacrylate does, however, possess two properties which are disadvantageous to its use as a denture base material, namely, its comparatively large curing shrinkage during processing and its relatively high water sorption. Obviously, any substance that is processed at a temperature higher than its environmental temperature during use will exhibit a curing shrinkage due to thermal contraction alone. Unfortunately, in the processing of an acrylic denture by dental techniques the thermal shrinkage is high and it may be augmented by other types of shrinkage as well.

It is also unfortunate that polymethyl methacrylate absorbs water to a considerable extent in comparison with some of the other types of synthetic resins. This water sorption causes a change in dimension of the denture, usually an increase in size. In any event, the increase in dimension of the denture during immersion in water or saliva does not always compensate for the curing shrinkage, and, therefore, a certain lack of dimensional stability must be accepted as one of the disadvantages of acrylic resin dentures.

A recognition of these disadvantages is by no means to be construed as a condemnation of the acrylic resins. Rather, if the disadvantages are recognized, much can be done in compensation. A critical analysis of the generally recognized techniques of processing can point out some of the reasons for these shortcomings and methods for their alleviation.

PREPARATION OF THE MOLD

It is assumed that an accurate cast has been obtained from an accurate impression. It is also assumed that the proper flask has been selected and that the proper investing procedure has been employed.

It is further assumed that the surface of the mold space is always covered completely with a layer of tin foil. It has been demonstrated in our own laboratory, as well as in the laboratory at the National Bureau of Standards,[4] that, to

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date, there has not been found an adequate substitute for tin foil as a mold liner. Not only do the tin-foil substitutes fail to protect the resin from a discoloration in the form of blanching during the processing period, but also surface strains appear in the resin whenever these materials are used.

MIXING OF THE POWDER AND LIQUID

Most of the denture materials available at the present time are dispensed in the powder-liquid form. These materials will, therefore, be given special attention.

The ratio of the monomer to the polymer to be used in mixing the two, preparatory to packing the case, should always be specified by the manufacturer of the resin. However, according to Peyton,[2] this ratio is quite critical in the case of some of the commercial products, and in some cases incorrect proportions are specified by the manufacturer of the resin.

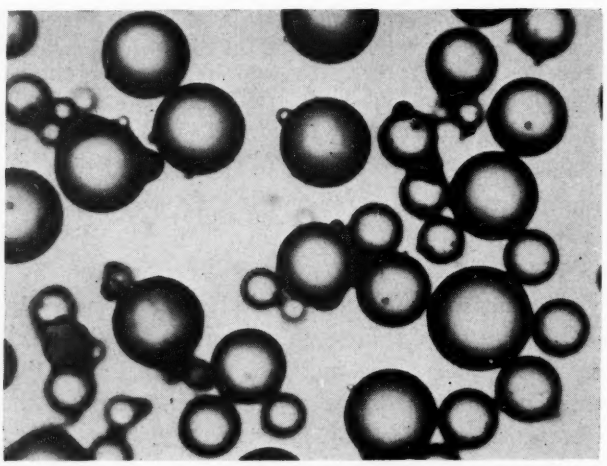

Fig. 1. — Pearls of polymethyl methacrylate (×100).

Fig. 1 shows the microstructure of a typical powder used in a denture resin. The particles are spherical in shape, and they are often called "pearls" because of their pearl-like appearance under the microscope.

When these pearls are mixed with the liquid monomer, the outside portion of the pearl is softened and dissolved by the monomer. As this solution proceeds, the mass becomes extremely tacky and sticky. Finally, when the solution becomes complete, a plastic dough is formed, which is soft and tends to be cohesive rather than tacky or adhesive. It is at this stage that the resin is packed into the mold. If it is packed earlier than this, a porous denture base will likely result, and if it is packed later, the plasticity of the mass will be so lacking as to prevent a proper molding.

The time required for the mass to reach the dough stage is governed by the modifiers in the resin and by the temperature during mixing. Also, the greater the size of the pearls and the molecular weight of the polymer, usually the longer the dough-forming time will be. If the time appears to be too long, the reaction can be hastened by cautiously heating the jar in warm water.

The "pot life," or time that the material can be maintained in the dough stage, will vary with different materials. Some materials will remain plastic in a closed jar for several hours, but others will remain in this condition without hardening for not more than 5 to 10 minutes. Refrigeration can be used to lengthen the pot life, but the objection to this procedure is that it is difficult, if not impossible, to prevent the condensation of moisture on the resin when it is brought to room temperature. Recent investigations[5] have shown that the presence of water in the mixture of monomer and polymer may affect the properties of the final product deleteriously.

THE TRIAL CLOSURE

The purpose of the trial closure is to insure that the mold is properly filled with resin when the curing takes place. This particular technique is probably the most important, and yet the most neglected and abused part of the entire denture technique. Unless the mold space is properly filled, the denture will not fit, regardless of the care that is used in the rest of the procedure. If the mold is underfilled, a porous and warped denture will result. If the mold is overfilled, a thick flash (that is, an exuding of the material from the mold onto the plaster surfaces during curing) will occur, and the mold space will be distorted, and an "open bite" will result.

The first trial closure should be made slowly, in order to allow time for the dough to flow into all parts of the mold under the pressure. The halves are then separated, and any overflow or flash is carefully trimmed away. If no flash occurs, it should be suspected that the mold was underfilled. In such a case, additional material should be added, and another trial closure made. The trial closure should be repeated until no flash is observed. Usually at least three trial closures are necessary.

The flask should be closed rapidly and under considerable pressure during the final closure[6] so as to confine the resin in the mold space with no flash. If a distortion of the denture base is to be avoided, there must be metal to metal contact between the halves of the flask. The investing medium (plaster or stone) is not sufficiently strong to bear the proper pressure by itself without distortion or fracture. Furthermore, a spring clamp is not indicated for use, unless the spring pressure is very great. A spring clamp may allow too much opening of the halves of the flask during curing, so that a flash occurs. It has been shown that the vertical dimension of the finished denture increases in proportion to the thickness of the flash.[7]

CURING CYCLE

The curing of the denture base consists of polymerizing the liquid monomer (methyl methacrylate) to a solid (polymethyl methacrylate). In this instance, the polymerization is brought about by the application of external heat.* The flask containing the denture is immersed in a water bath at a specified temperature for a specified time. The strength of the polymerized resin is definitely dependent on the degree of polymerization,[8] and the degree of polymerization is, in turn, dependent on the time and temperature of the curing procedure.

*The use of the "self-polymerizing" resins is not being considered at this time.

Unfortunately, the rate of curing is not entirely dependent upon the temperature of the water bath itself. The polymerization reaction is exothermic in nature, and as a consequence an internal heat is produced in addition to the external heat. In bulky portions of the denture, such as the distal end of a large lower denture or the bulky ridge of an upper denture, the internal heat may accumulate during a rapid rate of polymerization because of the fact that it cannot be dissipated rapidly by thermal conductivity in a material which is a good heat insulator. The rise in temperature resulting from such a heat accumulation would not be serious if it were not for the fact that the residual monomer, not yet polymerized, is caused to boil, and as a result blebs and porosity are produced in the resin. Methyl methacrylate (monomer) boils at 100.3°C. (212.5°F.), a temperature which is a fraction of a degree higher than the boiling temperature of water (100°C., 212°F.). Consequently, if the curing cycle is accomplished in boiling water during the early stages of curing, a relatively small accumulation of internal heat may produce a porosity of the thick portions of the denture.

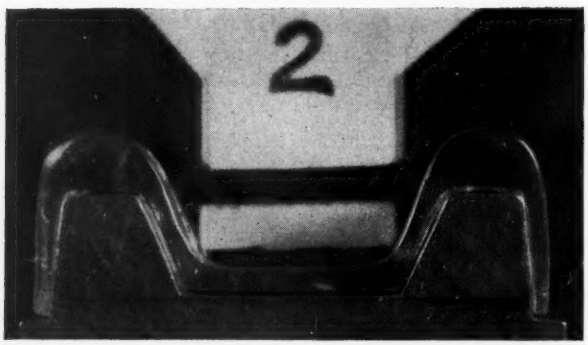

Fig. 2.—Specimen of acrylic on a test model after processing.

The remedy for such a situation is to reduce the rate of polymerization and thus reduce the rate at which the internal heat is produced. This result can be accomplished either by raising the temperature of the water gradually to boiling, or by curing at a lower temperature for a longer time. However, the lowering of the temperature of cure results in a proportionately greater length of curing time. For example, if a thin section of acrylic resin is cured at 71°C. (160°F.) for 1 hour and then cured at 100°C. for 0.5 hour, it will attain a better strength than will a similar specimen cured at 71°C. (160°F.) for 9 hours with no boiling.[10] A curing cycle which will probably result in a proper cure of acrylic denture base would be to hold the case at 65 to 70°C. (150 to 160°F.) for at least 90 minutes, and to boil it in water for 30 to 60 minutes.

After the curing has been completed, the case is removed from the curing bath and cooled to room temperature before the flask is opened.

DENTAL INJECTION MOLDING

The so-called dental injection molding process is a method for processing a denture, first developed by Pryor.[11] The case is flasked as usual, except that an ingate is provided to the mold space for the injection of the dough under

pressure applied from the outside. The case is subjected to trial closures in the usual manner, but not as great care needs to be taken in the proper filling of the mold, since the material is under pressure from the outside during the curing procedure. Under these conditions the mold is always properly filled automatically, and in this respect the injection molding process is superior to the conventional or compression molding process.

There can be little difference in the two methods, however, once the first stages of polymerization are over. There is certainly no difference in the curing shrinkage as shown by the results given in Table I for five commercial denture base materials. Resin D is a vinyl-copolymer acrylic resin, and the other resins are of the usual acrylic type. Certainly any difference in the figures in the two columns is insignificant and within the limit of experimental error.

TABLE I

CURING SHRINKAGE OF DENTURE RESINS

RESIN	CURING SHRINKAGE	
	COMPRESSION (%)	INJECTION (%)
A	0.35	0.31
B	0.33	0.35
C	0.50	0.51
D	0.28	0.26
E	0.39	0.42

These results in Table I are in agreement with the conclusions of Grunewald[18] in this connection.

DIMENSIONAL ACCURACY AND STABILITY

The results of our research are definitely in agreement with those of Worner[3] that the dimensional accuracy of the modern acrylic resins is not as good as that exhibited by the vulcanite of past years. For example, when a specimen of standard denture base acrylic resin is processed against a metal model in the conventional manner, and then returned to that model, a typical result is obtained, as shown in Fig. 2. It should be noted that the model contains no undercuts, as is the case with all of the experimental cases hereinafter described. The "palate" discrepancy as shown in Fig. 2 cannot be noted as definitely when undercuts are present. When undercuts are present, the denture base must be forced over the undercuts when it is seated on the cast, and thereby the denture base is made to conform to the cast more or less under elastic stress.

Obviously, the specimen shown in Fig. 2 cannot be entirely comparable to a typical denture base containing teeth. Furthermore, subsequent researches have shown that the dimensional stability is not the same when the resin is processed against a stone cast. In general, the curing shrinkage is the same, but the change in dimension when the denture base is immersed in water is likely to be greater when the resin is processed against the metal model. Furthermore, it has been shown that the denture base does not shrink equally in all dimensions during processing.[7]

When experiments were conducted using identical dentures with a full complement of porcelain teeth, it was found that the operator had little or no control of the curing shrinkage in certain instances. In these experiments, the curing shrinkage was measured in reference to marks placed on the posterior ridge portions of the case before processing and imprinted into the denture base during curing. A commercial denture acrylic resin was used. The cases were processed by both compression and injection molding[9, 14] under the most controlled conditions possible, according to the best techniques known to the experimenters. The results of these researches are shown in Table II. The water sorption was obtained by comparing the distance between the gauge marks on the dentures during immersion in water with the similar distance as measured on the case. The measurements were continued for a period of 7 to 9 weeks, with the dentures immersed in water at 37°C. (98.6°F.). The data presented in Table II represent the average of the final readings taken for water sorption. The data are the averages of measurements on a total of 17 experimental dentures. The columns labelled "Exp." represent the data obtained on experimental acrylic specimens as shown in Fig. 2.

TABLE II

DIMENSIONAL CHANGES OF ACRYLIC DENTURES AND EXPERIMENTAL SPECIMENS

	COMPRESSION MOLDED		INJECTION MOLDED	
	DENTURE	EXP.	DENTURE	EXP.
Curing shrinkage (%)	−0.58	−0.50	−0.55	−0.51
Water sorption (%)	+0.11	+0.54	+0.37	+0.55
Net change (%)	−0.47	+0.04	−0.18	+0.04

The first point to be noted is the fact that the curing shrinkages are the same (within the limits of experimental error) regardless of the type of specimen or method of processing.

The amount of linear change presumably due to water sorption varies considerably, however, with the different specimens and methods of processing. When the linear measurement for water sorption was added algebraically to (or subtracted numerically from) the curing shrinkage, in order to obtain the net change or presumably an indication of the final error in the denture, the linear change of the resin specimens cured against a metal model completely compensated for the curing shrinkage in both cases (Table II). On the other hand, the dentures which were processed against a tin-foiled stone cast failed to return even approximately to their original dimensions during water sorption.

It is interesting to note that the net change for the dentures molded by compression indicates a greater error than does the similar change for the injection molded specimens. In our hands, the curing shrinkage was not always under control. When two dentures were processed by compression molding in different flasks, but in the same flask clamp, occasionally one of the dentures would shrink perhaps only one-fifth as much as the other. In every case, however, the dentures shrank for the first day or two after they were immersed in water before

they began to expand. It is for this reason that the final shrinkage, or net change, of the denture was so great. In the case of the dentures molded by the injection method, an initial linear shrinkage occurred after the dentures were immersed in water, but it was not as great in magnitude as in the other case; consequently, the final error, or net change, in the denture was not as great.

It should not be inferred from the data in Table II that dentures processed by injection molding are necessarily more stable clinically than those processed by compression molding. The difference in accuracy between the two methods as shown by the net change (Table II) is not great. The actual average error in the posterior dimension of the dentures processed by the compression method was 0.2 mm., and the similar error for the dentures molded by injection was 0.1 mm. Very likely the average difference in error between the two methods of processing (0.1 mm.) is not of clinical importance.

The general errors involved in processing dentures by either technique are, however, possibly of clinical importance. Some other type of resin or processing which would reduce these seemingly inherent errors would be a decided step in advance of present practices. Although the present prosthetic materials and techniques are excellent in comparison to past achievements, there is apparently still room for progress and further achievement.

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HAS THE ADVENT OF PLASTICS IN DENTISTRY PROVED OF GREAT SCIENTIFIC VALUE?

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IT is now more than ten years since Harold Vernon first introduced the use of methyl methacrylate in the form of a powder and liquid to be used as a denture base. Since then the use of this material in denture construction has advanced by leaps and bounds. As to the originality and practical application of acrylic resins as used in dentistry, our best evidence should be the records of the United States Patent Office. The basis upon which the government patent examiners are supposed to grant a patent is that the idea must be new, original, and useful.

It should be understood that the advent of plastics (not acrylic resins), as we know them in dentistry, has resulted in marked changes in prosthetic work. Then, too, the commercial dental concerns have spent millions in the development and manufacturing of equipment and plastic materials to fit the needs of our profession.

If we would care to be technical it may be said that plastics are not new; that vulcanite, celluloid, phenolic compounds, and other materials are plastics; but when this subject is discussed among dentists the term "acrylic" is applied to almost every form of new resins. Considerable confusion occurs in the classification of plastics; for example, it is common to hear a dentist or laboratory man remark "this is 'Luxene' a vinyl resin base, not an acrylic." Actually the polyesters of vinyl alcohol and the esters of acrylic and methacrylic acids, and even polystyrene, all belong to the vinyl group of resins; therefore, so-called "acrylic" may actually be a vinyl resin.[1]

When the demand for a dental product shows a marked increase over a period of years, there is every reason to believe that the material possesses properties of some scientific value. The manufacture and sale of resinous denture base material developed in the United States has, in less than ten years, grown from a few hundred pounds to an estimated 200 tons or more for the year 1946, sufficient material to make more than five million dentures.*

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*Mr. B. F. Cooling of the Chemical Division of the Department of Commerce stated in a letter: "In 1945 the output of acrylates and methylacrylates is said to be well over 35 million pounds level . . . what portion of product . . . consumed by dental trade is not known." From this report it would seem reasonable to suppose that our profession would use at least 1 per cent plus of the total amount mentioned, or at least 350,000 pounds, especially if we consider the increased demand of two years later.

It is apparent that the use of plastic materials in dentistry has not only resulted in a tremendous increase in the sale of the material, far beyond any other class of dental products, but has reached a point which indicates universal acceptance by the profession.

In the early years of what might be referred to as the "Plastic Age in Dentistry" researchers and experimenters used plastics for every form of dental restoration. During the period from 1939 to 1944, teeth, jackets, bridges, inlays, and so forth, in addition to dentures, composed chiefly of an acrylic resin, were used indiscriminately by many dentists and laboratories. A recent brief survey of the Chicago laboratories, including interviews with dentists who have used plastics in various mouth restorations, disclosed this important fact: The use of plastics in dentistry, other than for denture bases, with the possible exception of denture teeth, has been almost discarded as a material for crowns, bridges, and inlays.

This brings us directly to two questions: First, why have plastics been universally accepted for dentures and discarded as material for crowns, inlays, and bridges? Second, why is it that prosthodontists are divided in their opinion on the soundness of using plastic teeth instead of porcelain teeth?

In answer to the first question it may be stated that no denture base material has ever been developed that possesses as many outstanding qualities as observed in the modern type of vinyl synthetic resins. Aside from the unsurpassed range in color, light weight, tissue tolerance, strength, resistance to the action of chemicals, and natural cleanliness, it is a material that may be processed into a denture without difficulty and finished to satisfy even the most exacting patient.

Possibly the greatest criticism of the acrylic base material is its tendency to change form. This is due in most cases to the internal forces (stress and strain) created by heat and pressure in polymerizing; then, too, some technicians are careless in their methods of processing. When porcelain teeth are used, there is the possibility of cracking, especially if the case is subjected to reheating, as for repairs, or when extra pressure is applied to a partially closed flask after polymerization has started.

Why, then, has this class of material, with all its outstanding properties, failed when used in the construction of crowns, inlays, and bridges?

The material prepared for this type of work is generally of slightly different structure and composition. The powder must be extremely fine, and the metallic coloring and fluorescent matter of the highest quality. Regardless of the technical care employed in constructing the article, the life of this restoration even in the most skilled hands is limited. Jacket crowns and inlays are inclined to loosen and, in many cases, the teeth become discolored. Inlays often present dark lines, or evidence of decay appears about the margins.

The main cause of these failures may be traced to the continuous physical changes going on in the plastic restoration and not, as some believe, to the cement support. It should be understood that moisture and changing mouth temperatures have a decided effect on all acrylic appliances, and the forces of mastication when applied under these conditions also cause difficulty. Possibly a better plastic material will be developed for this work, but for the present we must wait.

PLASTIC TEETH

Let us consider now the most widely discussed subject in the prosthetic field today, namely, "plastic teeth." It might be mentioned here that there is a marked difference of opinion regarding these teeth. However, in determining the scientific value of this type of tooth we must consider first the facts and the evidence obtained from dentists who have actually used and studied these teeth in the mouths of patients, and not depend upon hearsay and imagination. The second consideration can best be answered by consulting with leaders in the dental trades. Again two factors enter the picture: First, has the demand and output of commercial plastic teeth increased? Second, have tooth manufacturers, with millions of dollars invested in porcelain teeth, finally become conscious that a rising demand for these teeth actually is occurring?

The facts are that not only has the business of the original producers of plastic teeth increased tremendously but every leading tooth manufacturer in the country has already spent thousands of dollars in plastic research, and is now actually manufacturing these teeth in astonishing quantities.

The dentists who have used these teeth in private practice have had every opportunity to observe and analyze the situation. What is the attitude of these men today? During several personal interviews your essayist asked questions like this: "If plastic teeth were a little harder, and would not crack or check with weak solvents, would they be acceptable?" Most of the replies were in the affirmative. Furthermore, some of the manufacturers are now ready to make startling claims for their new plastic teeth, which means that again the profession will become the agents for more clinical experimentation.

Regardless of what the future holds for plastic research and development, let us review some of the clinical reports as observed in years gone by. It has been my fortune for many years to have directed a plastic research chemical laboratory in connection with my dental practice. Since February, 1939, in 95 per cent of all dentures made in my laboratory, plastic teeth have been used. Before this type of tooth was commercialized, a polymer-monomer acrylic resin was used in constructing the teeth for all the cases. It should be emphasized that this early work was strictly clinical research. When it became evident that plastic teeth had a place in dentistry, exacting records were made of all cases and these were checked from time to time to note color and physical changes, wear, and, in particular, the reaction of the patient.

Tooth manufacturers are producing teeth for the use of the average dentist; yet suggestions for improved tooth forms, mechanics, and clinical information come from men who give careful consideration and study to the relationship of the manufactured article to the structural basis for which it is to serve. The mistake of tooth manufacturers in determining the value of their product lies in failure to extend research into the clinical field with the same exactness put forth in plan development. It is only hearsay evidence, and scattered reports from men who suddenly take an interest in some tooth form, color design, or tooth structure, that affords a working key for the manufacturer. There is a presumption that progressive manufacturers are not only interested in the dentists' opinion of their product, but that they are ever on the alert to improve the

article according to knowledge within their own sphere. The word "sphere" should be understood as referring to the mechanical testing laboratory, plus logical reasoning not closely associated with the clinical facts. Let this be illustrated by an old, well-established belief that tooth hardness, without brittleness, is the chief prerequisite for an artificial tooth. As a consequence, the expert ceramist, chemist, and physicist are put to work with the erroneous idea that hardness constitutes the prime essential of a desired product. Manufactured tooth forms are the result of some artistic carving expert applying his talent to reproducing an exact specimen of a formed natural tooth. On some occasions a deviation is made to design a strictly mechanical tooth by an engineer whose training has been developed on the drawing board, not in the human mouth where the article is supposed to function.

Unless the laboratory research department extends its activities into a systematic coordinated clinical field, we shall continue to focus attention upon the esthetic qualities of the tooth rather than upon establishment of masticating efficiency.

ARTIFICIAL TOOTH DEVELOPMENT

It has been a long time since George Washington is supposed to have received his ivory teeth, but we are able to make a very good check on tooth development since that time. For more than a century, the basic material used in the manufacture of artificial teeth has been porcelain. Most of the research advances in artificial tooth construction have been concerned with this product rather than experimental investigation into other materials. Many substitutes for porcelain teeth have been offered, but only within the last eight years have commercial tooth manufacturers indicated a serious interest in the matter. The only material at present which appears to encroach upon the porcelain tooth field is synthetic plastic. Just what will be the ultimate outcome so far as teeth of this composition are concerned, it is difficult to state. It must be recognized that the original research and experimentation with plastic teeth was not undertaken by the manufacturers, but was instituted by dentists in their own practices.

TOOTH FORMS

There can be no question about the improvement that has been made in porcelain teeth, especially in the shades and tooth forms. One noticeable change has been of particular interest, that is, discarding of the high cusps and deep sulci formerly so evident on posterior teeth. The reduction of cusp prominence on posterior teeth is of course not new, but it now becomes apparent that manufacturers are recognizing the growing demand for mechanical tooth forms. One reason why dentists and technicians lean toward the low cusp, semianatomic tooth is their ease of "setting-up" in a time-saving manner. It must be recognized that not many dentists or technicians are able to articulate accurately a set of anatomic artificial teeth on an articulator, that can be placed in the mouth with perfect balanced occlusion, and without some cusp interference when in function. Flat occlusal posterior teeth in numerous designs have received attention, with Hall's inverted cusp teeth still predominating in this field. In the continual

debate on tooth forms, there is still wide diversity of opinion as to size and shape of the posterior teeth. Ever since French introduced the idea of narrow lower teeth, buccolingually, there has been a trend toward making teeth of this design. One of the chief claims made for this narrow tooth is that more tongue space is possible and that there is less possibility of breakage. On the other hand, many men contend that occlusal balance can best be obtained by using teeth with larger occlusal surfaces, and that, therefore, mastication is accomplished with far less crushing force and effort.

The writer desires to express his own views based primarily on clinical observation. These deductions relate to artificial teeth made of plastics and not of porcelain.

The first observation is that the manufacturer and dentist should anticipate the wearing down of plastic teeth. This is, strange as it may seem, the outstanding recommendation for this type of tooth. Either the artificial tooth must yield as the patient gradually establishes occlusal balance in the process of mastication, or the interfering cusps will cause destruction of the ridges which support the dentures.

Every patient has an individual jaw movement, and no accurate method of mandibular tracing is possible except by application of time and masticating function. The occlusal surface should present reasonably flat planes, and there should be no attempt to reproduce nature's "compensating curve" which is so evident in natural teeth at an early age. From clinical study of plastic wear, there is every evidence to indicate that occlusal balance can best be maintained on a flat plane or a slight pitch in reverse on posterior teeth. This clinical observation tends to support McGrane's and Kurth's[2] analysis of the jaw movement which provides for a flat template, rather than giving support to Monson's spherical theory of occlusion. These men contend that a tooth arrangement in this manner insures far better masticating efficiency.

The occlusal form and alignment of posterior teeth should be so designed as to anticipate that there will be a horizontal space between the upper and lower anterior teeth of approximately 2 millimeters. This space between the lingual surface of the upper anterior teeth and the labial surface of the lower anterior teeth should be regarded as a relief for the forward movement of the lower jaw as the posterior teeth are worn down to centric balance. The composition of plastic teeth should be hard enough to stand the ordinary masticating wear, but the teeth should wear down in the course of service to the patient's individual functional movement.

COMPARATIVE WEAR OF PLASTIC TO NATURAL TEETH

It is well understood that porcelain teeth are much harder than either natural or plastic teeth, and it is also acknowledged by manufacturers of plastic teeth that these teeth will yield to masticating force far more rapidly than either the porcelain or natural tooth. It is not generally known that the wearing away of plastic teeth follows the same lines of attrition as noted in natural teeth in old age. The important thing in plastic tooth wear is not how much the loss, but how and where does this wasting away occur on the contacting surfaces?

It seems logical that the greater amount of wear will occur in areas subjected

to the most use, presuming that the physical structure of the teeth is the same. It is also reasonable to believe that mandibular movements will record the direction of the masticating force on the functioning tooth surface. Any yielding or breaking down will register the inclined plane of the individual characteristics. It has been mentioned that plastic tooth wear follows the same general lines of old age, but attention is directed to a very important distinction. Natural teeth do not "float" around like dentures but are reasonably fixed. As a consequence, stabilization of the dentures depends upon a balanced relationship of all the working teeth. Eccentric conditions in dentures where plastic teeeth are used usually reach a centric balance by the wearing down of the teeth, which is almost impossible where hard porcelain teeth are used.

It should be repeated that eccentrically balanced dentures worn in the mouth with interfering tooth points or cusps will either cause the teeth to wear, or the ridges which support the appliance will sooner or later give way. It is my clinical observation that in all the patients examined, where there was any evidence of wear, only a very small percentage presented a uniform, bilateral wearing down of teeth. Nearly everyone gave indication of favorable biting or chewing areas. Where the dentures were worn more than two years, the original "pitch" or masticating plane was changed, in some instances to a complete reverse inclination. The most noticeable destruction of the original tooth form is found in the lower teeth; often the entire bucco-occlusal angle of the posterior teeth was destroyed.

It should be pointed out that clinical observation of attempts to use plastic teeth in combination with porcelain or metal appliances will always, in the course of time, result in breakdown of the former. The same is true where posterior porcelain teeth are used in the same denture with anterior plastic teeth. For instance, if an upper denture with a combination of this kind is used in a mouth with natural lower teeth, it will be observed that contact will be lost on the plastic tooth area of the denture in a short time.

In a clinical case of a full upper and lower plastic denture, where the patient had a very large gold inlay placed in his right upper cuspid tooth (plastic), the entire occlusal plane was changed as this one tooth cut a path in the plastic teeth of the lower denture. This one interfering inlay caused a reversal of the tooth pitch on the right side and increased the compensating inclined plane of the left.

From all the evidence we have at hand covering this period of several years, there is a strong confirmation of Pleasure's[3] study of natural tooth wear resulting in a change in the occlusal pitch of the bicuspids and molars. However, in his article it is stated that "upper teeth (natural) commonly show more wear than lower." This remark is at variance with our observations in this survey. In Pleasure's report, he deals specifically with the changes in the occlusal plane due to tooth wear in an advanced stage of life. His analysis is based upon the study of thousands of skulls and he remarked "we were enabled to study the museum collection of almost 12,000 human skulls." In commenting on the wearing down of the natural teeth in these specimens he adds, "The interfering eminences would be first to wear away and the non-interfering areas would tend to persist almost unchanged . . . another phenomenon of interest, the reversal of pitch as we approach the last molar."

This last remark is in conformity with the observation made by the writer where plastic teeth had been worn for two or more years. Pleasure also states that some of the inclined planes of the worn-away teeth represented in part Monson's spherical theory, as well as the reverse curve which reduced the buccal cusps of a few of the lowers to a change in the occlusal plane. This last analysis is also in conformity with the wearing away of plastic teeth as indicated in this survey.

WEAR AND CRAZING

From my clinical file of many other patients wearing dentures with plastic teeth, notation has been made indicating that some destruction of the teeth has occurred other than by ordinary masticating wear. For example, in some cases we find teeth badly checked with small surface cracks; in others, the surface has become granular and rough. It is difficult to state just what is the exact cause of these defects, but this we do know: Our present commercial teeth, incased in a denture base, will "craze" on the application of solvents, including cleaning agents, acrylic monomer, chloroform, alcohol, and many other agents. The breaking down of the plastic teeth from solvent reaction appears to be due to the sudden liberation of internal stress and strain within the teeth themselves. Recently there was placed on the market a new noncrazing plastic tooth, which the manufacturer claims will not check or crack on direct application of acrylic monomer or alcohol after being processed in a denture. This is of interest to the technician as, in denture tooth repairs, if the monomer contacts the adjoining teeth, crazing follows. Alcohol and other solvents are, as a rule, not destructive to plastic teeth, but many times the breaking of a plastic denture can be traced to the solvent.

Alcohol.—When a plastic tooth is placed in pure ethyl alcohol for several hours, the tooth will swell and soften and may be pushed out of shape. On the other hand, if this same tooth is processed in a denture where forces (stress and strain) are a different relationship to the baseplate material's physical characteristics, the application of 20 per cent alcohol to the tooth will result in crazing or surface checking, and ultimate breakdown of the tooth itself.

Lipstick.—Certain oils and greases are very destructive to plastic material. In the automobile industry it was found that secretion from the hands was responsible in many cases for the breaking down of the plastic steering wheel of the car. In four cases in our clinical record the labial surfaces of the upper anterior teeth were deeply pitted and rough (abrasion) due to the lipstick used by the wearers.

Denture Cleaning Materials.—At the present time there is no safe cleansing material for plastic dentures, and it is quite possible that leaving dentures in certain advertised cleaning agents may be responsible for some structural breakdown of the teeth or the base material. It is claimed by the manufacturers of methyl methacrylate resins that their materials are not affected by acids and alkalies. This is true to a limited degree, but where we get into trouble is that the denture base and teeth are not pure acrylic resins, and usually contain some metallic coloring matter which quickly yields to acids and alkalies.

CLINICAL REPORT

A standard of "setup" was used in the clinical cases which have been discussed. Whenever possible, a template with a 5.5 inch radius was employed. All dentures (or splints) made during 1938, 1939, and up until the middle of 1940 (more than 150 dentures) had the "tailor-made" teeth, that is, made with monomer-polymer mix (M.P.).

In these early cases, the monomer-polymer plastic teeth were polymerized at the same time as the pink base material. This was done by using porcelain teeth in the wax setup; then, after flasking, these teeth were removed so that the mold forms could be used for the tooth-colored plastic mix to form the teeth.

In 1940, the first commercial plastic teeth were also made of the monomer-polymer mix. Later (1941) the Justi Company changed to dry powder molding and have continued this method until the so-called Cyclo injection process was announced in 1945.

The subject of crazing has always been a vital issue in connection with plastic teeth when subjected to solvents. Two facts should be mentioned: First, the application of solvents to plastic teeth which are made with the denture base in a single processing operation rarely results in checking or crazing. Second, where plastic teeth are made separately, using a polymer-monomer mix, and are later processed with a denture base material, they will sometimes check or craze with solvents; on the other hand, all straight polymer plastic teeth (heat-molded) now on the market will crack in the cured denture if subjected to solvents.

While crazing and tooth wear are both destructive factors in plastic teeth, they are not alike. Worn surfaces where crazing has occurred become rough and crystalline. Also, variations occur in plastic tooth wear, as no two mouths wearing dentures follow the same lines of destruction. Several recorded clinical cases where monomer-polymer teeth were used presented evidence of a plastic "cold flow" rather than the appearance of "sugarlike" crystallization so noticeable in straight polymer teeth which have been worn for some length of time.

In order to determine the extent of tooth wear, certain measurements of the face and of the teeth must be recorded, and periodically checked. In all cases, definite positions were considered for denture measurements; namely, the region of the central incisors and the first molars on each side. These three measurements were obtained with a millimeter gauge. They were taken from the deepest inside depression of the denture to the highest cutting edge or cusp plane in a perpendicular line. All cusps and interfering points were first reduced to an occlusal balance before recording the measurements.

VERTICAL DIMENSIONAL CHANGES

While it is the general rule that the vertical dimension is shortened as the contacting tooth plane surfaces wear away, it was observed that tooth destruction did not appear to reduce the original dimension in two cases made with end-to-end bites. In one instance the vertical dimension was apparently increased. The only explanation for this change is that the habitual protrusion of the mandible may have affected the condylar relationship to the glenoid fossa. Some authorities on anatomy have contended that there is no change in the temporomandibular

joint after maturity has been attained, but from a few clinical records it would appear that the original position of the jaw has moved in some edentulous cases.

I once heard a well-known prosthodontist state that the reason he used cusp teeth was because they acted as a retainer for uncontrolled movement of the jaw. It is extremely doubtful, however, that a floating mouth appliance with cusp teeth would keep a muscle-powered jaw in adolescent relationship.

SUMMARY AND CONCLUSIONS

1. All-plastic teeth will, in time, yield to the forces of mastication.
2. Plastic teeth made from a straight polymer, while harder, are brittle, and are inclined to be "sandy" as they break down.
3. Monomer-polymer teeth usually show evidence of "cold flow" in yielding to continued use.
4. No matter how the occlusal plane has been established, a change in the tooth form follows the inclination of the individual jaw movement.
5. Masticating efficiency has very little relationship to the cusp or noncusp form of the teeth. In other words, gradual "wearing-in" to an occlusal balance is more important than the mechanics of cusps for masticating purposes.
6. As a general rule, where patients have worn both upper and lower all-plastic dentures, the bucco-occlusal surface of the lower bicuspids and first molar break down more rapidly than the lingual side of these teeth. On the upper denture this process is reversed, the lingual occlusal surface giving way first.
7. All-plastic dentures with teeth arranged on a compensating template curvature will show, after a considerable time of masticating use, that the incline or "pitch" of the bicuspids and first molars are reversed, while the second molars retain their original inclination.
8. In the case of any hard structural interference such as porcelain or alloyed gold against plastic, the plastic teeth will wear away more rapidly than they would if they were in contact with plastic teeth.
9. Posterior teeth break down before anterior teeth, and lower anteriors before the upper anteriors.
10. Vertical dimension losses are not always in accordance with the combined occlusal tooth wear.

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A COMPARISON OF THE MECHANICAL PROPERTIES, CHEMICAL COMPOSITIONS, AND MICROSTRUCTURES OF DENTAL GOLD WIRES*

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INTRODUCTION

A survey of the technical literature indicated that no general correlation had been made of the mechanical properties, chemical composition, and microstructures of the wrought gold alloys. Such data would be of interest, since it might reveal some fundamental relationship between the mechanical properties and the chemical composition or the microstructure, or between chemical composition and microstructure.

Work by Wise and Eash[1] compared chemical composition and microstructure. Carter[2] investigated the relationship between chemical composition and mechanical properties of some gold alloys. Similar investigations were also conducted by Paffenbarger, Sweeney, and Isaacs[3], Coleman[4], and Wise, Crowell, and Eash[5].

Selected values for tensile strength and hardness have been taken from some of these papers and have been compared to the results obtained from this series of experiments. The properties examined in this study were Vickers diamond pyramid hardness, ultimate tensile strength, tensile proportional limit, elongation, proportional limit in bending, springback after bending, chemical composition, and miscrostructure of the softened (as-quenched) and hardened alloys in wire form.

MATERIAL

All alloys were the standard commercial products, representing the composition and property range normally met with in wrought gold dental alloys. A total of twelve alloys were investigated. These alloys were supplied by the following companies:

Handy and Harman (Dee) Co.	Chicago, Ill.
J. M. Ney Company	Hartford, Conn.
Spyco Smelting & Refining Co.	Minneapolis, Minn.
The S. S. White Dental Mfg. Co.	Philadelphia, Pa.

They were in the form available to the profession, as wrought wires with the heat treatment, if any, that is normally performed by the producer before release.

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The alloys were obtained as 0.040 inch diameter wires, suitable for tensile and bend tests. Some comparisons of tensile and bend properties have been given in another report.[6] The chemical compositions of the alloys are given in Table I.

TABLE I

CHEMICAL COMPOSITION OF DENTAL GOLD WIRES

ALLOY*	CODE	ANALYSIS (PER CENT BY WEIGHT)						
		AU	PT	PD	AG	CU	ZN	NI
10	A	54.3	17.0	7.0	8.2	12.5	1.0	—
6	B	63.0	7.0	5.0	10.5	12.0	0.5	2.0
4	C	63.0	2.0	2.0	14.5	18.0	—	0.5
11	D	55.0	17.0	7.0	6.5	13.0	1.5	—
8	E	63.0	7.0	5.25	10.0	12.25	0.5	2.0
3	F	61.5	2.5	3.0	14.5	18.5	—	—
9	G	55.0	17.0	7.5	8.0	11.0	1.5	—
12	H	15.0	9.0	37.0	21.0	15.0	1.0	2.0
1	I	56.5	—	5.0	25.0	11.0	—	2.5
7	J	60.0	16.0	—	12.5	9.6	1.2	—
2	K	66.6	4.1	—	12.5	15.8	1.0	—
5	L	30.0	5.1	10.1	37.6	17.2	—	—

*Coding used in reference 6.

HEAT TREATMENT

All alloys were heat-treated before testing. In most cases, they apparently had been heat-treated by the manufacturer. To insure a uniform treatment of each product, the as-quenched state (soft) was obtained by heating the wires for 10 minutes to 1290°F. (700°C.) and quenching in water. The hardened state was obtained by reheating for 15 minutes to 680°F. (360°C.), followed by a water quench. For some of the specimens examined microscopically a similar heat treatment was used, but the variation in temperature was very closely controlled, as was the time both in obtaining softened and hardened specimens. In this case a small electric furnace, in which the maximum variation in temperature was ±4°C., was used to heat to 1283°F. (695°C.). Two sections of all alloys heated together for 10 minutes were water-quenched rather than each product being given a separate heat treatment. The second section was reheated to 680°F. (360°C.) for 15 minutes and water-quenched to obtain the wires in the hardened state. With this procedure, the possibility of excess grain size, due to overheating of some samples and not others, was eliminated, and a comparison of the different alloys using one arbitrarily selected condition of heat treatment was assured.

TEST PROCEDURES

Tensile tests, bend tests, and Vickers hardness tests were performed on the wires. In the case of the tensile tests, a Tinius Olsen mechanical drive machine

was used. The wires were loaded at a rate of 20,000 psi/min. The strain was determined with Lowe dial gauges on a gauge length of 2 inches as described in another report.[6] In each case the length of wire between the grips served as a medium of comparison in determining the elongation, and no correction or reruns of the tests were made if the wires broke at the grips or broke due to flaws. As a result, the values obtained are somewhat lower than those obtained by Paffenbarger, Sweeney, and Isaacs[3] since these authors reran all such tests. Bend tests were made on a Tinius Olsen stiffness tester, using 2 inch wire lengths.[6]

It was felt that the most accurate method of determining the hardness of the wires would be by a diamond pyramid hardness or a Knoop indenter. Initial tests on the wires were made after first mounting in Lucite and polishing metallographically. For low applied loads, neither the Knoop indenter nor the diamond pyramid proved to be satisfactory due to the scatter in results. By shifting to a Vickers hardness tester using a 10 kg. load and a 136° diamond pyramid point, this scatter was eliminated. In general, the deviation was no more than $\pm$ 1 filar unit, which was within the personal error. This corresponded to an error of $\pm$ 0.002 mm. All results determined in this fashion proved to be satisfactory.

A specialized metallographic polishing technique was developed, since results were not satisfactory when the usual procedures were applied. The wires were mounted in Lucite, then polished through a 000 metallographic paper. The samples were then transferred to a wheel covered with a billiard cloth and using 65F polishing solution. This was followed by an intermediate polish on a low speed wheel covered with a silk velvet cloth and using a C-RO polishing solution. The final operation was similar to the intermediate. The same type cloth and wheel were used but a Gamal solution was substituted for the C-RO solution. Extreme precautions were necessary to prevent contamination of the wheels by small particles of dust or dirt. Such contamination immediately resulted in severe scratching necessitating repolishing as far back as the metallographic papers.

The most satisfactory etchant proved to be a freshly prepared solution of 10 per cent potassium cyanide and ammonium persulfate as suggested by Wise and Eash.[1] It was found that varying the concentration from 20 per cent to as low as 5 per cent was often necessary since some of the alloys etched too rapidly with a concentrated solution while other alloys did not etch noticeably after several minutes at the lower concentrations.

RESULTS

The mechanical properties investigated in this report are tabulated in Tables II and III. The ultimate tensile strength, tensile proportional limit, elongation, and diamond pyramid hardness values are given in Table II. Proportional limit in bending, springback, and diamond pyramid hardness are contained in Table III. An analysis of these results in given under the discussion.

The typical microstructures of the alloys in the soft (as-quenched) and hard state are shown in Figs. 1 and 2. In Fig. 1 the typical microstructures characteristic of the alloys in the softened and hardened state are given at 100 diameters. In Fig. 2 the microstructures of the softened and hardened alloys are shown at 1,000 diameters. At the higher magnification, it is possible to detect any changes

TABLE II

MECHANICAL PROPERTIES OF DENTAL GOLD WIRES

ALLOY*	CODE	PROPORTIONAL LIMIT (TENSION)		ULTIMATE TENSILE STRENGTH		ELONGATION BETWEEN GRIPS		DIAMOND PYRAMID HARDNESS	
		SOFT	HARD	SOFT	HARD	SOFT	HARD	SOFT	HARD
10	A	72,400	107,700	114,800	135,700	11.5	7.1	236.8	278.8
6	B	69,200	129,320	111,500	163,800	13.4	6.0	230.0	300.4
		67,000	———	107,300	———	14.0	———	227.6	———
4	C	55,000	101,430	86,700	130,700	30.0	2.2	202.8	276.0
11	D	95,250	129,600	130,800	167,800	9.4	6.9	289.4	352.2
8	E	87,000	128,230	115,800	152,800	13.9	4.8	221.0	323.0
3	F	49,700	92,500	81,200	129,200	36.6	3.1	165.5	290.7
9	G	66,900	100,730	108,200	135,700	19.7	9.5	239.3	276.0
12	H	79,800	107,830	126,000	142,200	18.9	8.9	196.4	245.4
1	I	51,700	97,800	90,700	140,500	16.1	1.9	173.6	285.6
7	J	65,700	94,800	100,800	128,500	18.1	7.3	183.8	266.0
2	K	49,450	84,870	75,200	112,700	34.8	3.1	190.5	254.5
5	L	58,000	89,300	87,500	115,200	16.9	3.2	162.0	244.0

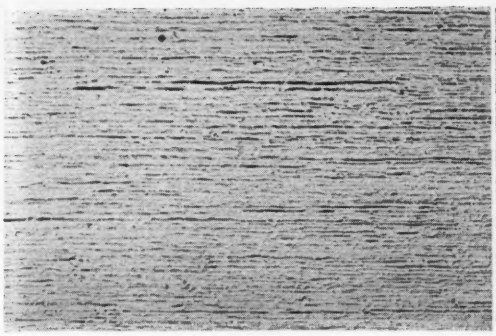
*Coding used in reference 6.

TABLE III

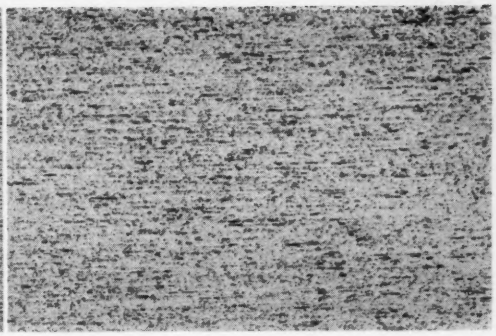
MECHANICAL PROPERTIES OF DENTAL GOLD WIRES

ALLOY*	CODE	PROPORTIONAL LIMIT (BENDING)		SPRING BACK (DEGREES)		DIAMOND PYRAMID HARDNESS	
		SOFT	HARD	SOFT	HARD	SOFT	HARD
10	A	145,400	178,130	18.0	21.6	236.8	278.8
6	B	127,000	211,100	16.9	25.2	230.0	300.4
		119,600	———	17.2	———	227.6	———
4	C	83,500	169,530	12.8	22.3	202.8	276.0
11	D	167,500	215,400	20.8	26.2	289.4	352.2
8	E	129,700	198,530	17.2	23.9	221.0	323.0
3	F	78,600	168,200	12.1	21.5	165.5	290.7
9	G	122,900	162,200	15.6	20.7	239.3	276.0
12	H	129,800	174,300	14.6	17.5	196.4	245.4
1	I	83,600	189,500	12.9	23.7	173.6	285.6
7	J	113,900	162,700	16.9	22.6	183.8	266.6
2	K	71,700	146,300	12.1	20.9	190.5	254.5
5	L	97,100	140,000	17.0	21.7	162.0	244.0

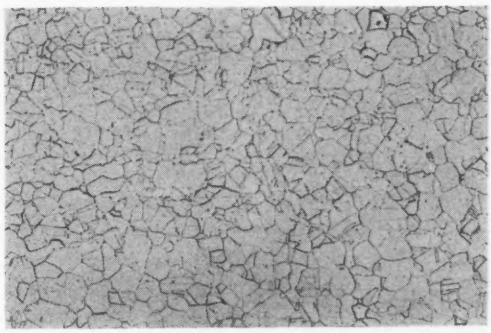
*Coding used in reference 6.



A, Alloy G—Soft (Alloys A and D are similar)

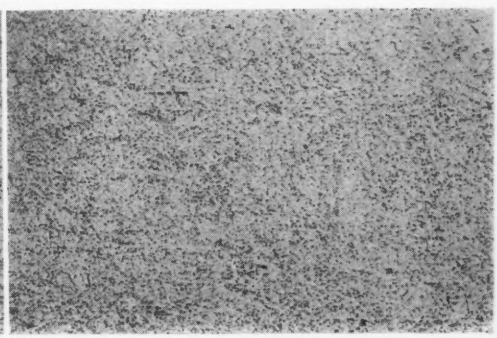


B, Alloy E—Hard (Alloy B is similar)

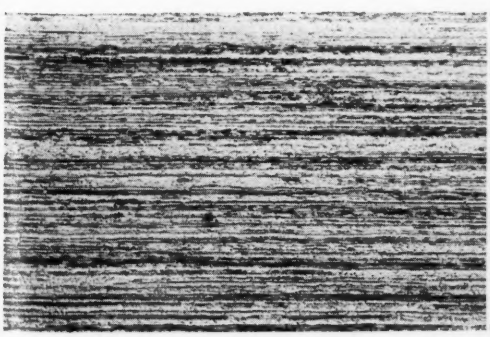


C, Alloy K—Soft (Alloys C and F are similar)

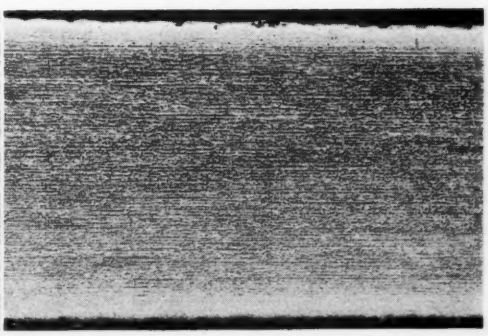
D, Alloy H—Hard



E, Alloy I—Hard



F, Alloy J—Hard



G, Alloy L—Hard

Fig. 1. — Typical microstructures of dental gold wires investigated. Ammonium persulfate-potassium etch. 100×.

in microstructure which occur when the alloys are hardened. It is also possible to compare the different alloys to detect similarities which are a function of the chemical composition. The photomicrographs also aid in predicting the approximate mechanical properties or chemical compositions since a definite relationship was found to exist between microstructure and chemical composition. In the majority of cases, the relationship between microstructure and mechanical properties was sufficient to predict the approximate values of these properties, provided the heat treatment was known, since the microstructure in the soft and the hard state are so similar.

DISCUSSION

Mechanical Properties.—The ultimate tensile strengths of the alloys were plotted against the diamond pyramid hardnesses (Fig. 3). Examination of the plot indicates that the values fell along a straight line. As a result, a regression and correlation analysis was undertaken. The results indicated that definite correlation did exist. This plot is shown in Fig. 3 together with the equation of the line fitted to the points as determined by a least-squares analysis (two points representing Alloy H in the soft and hard condition were not included due to their extreme variance). A comparison of the results of other authors[3] was also made, as indicated on the graph in Fig. 3. It is obvious that there is an excellent correlation between the experimental results of this study and those of Paffenbarger, Sweeney, and Isaacs.[3] The uniformly higher results obtained by these authors is believed to be due to their method of performing the tensile tests where specimens were rerun when they broke outside the gauge marks. Since this practice was not followed in the tensile tests performed in this study, it is obvious that the general level of the tensile strengths will be lower.

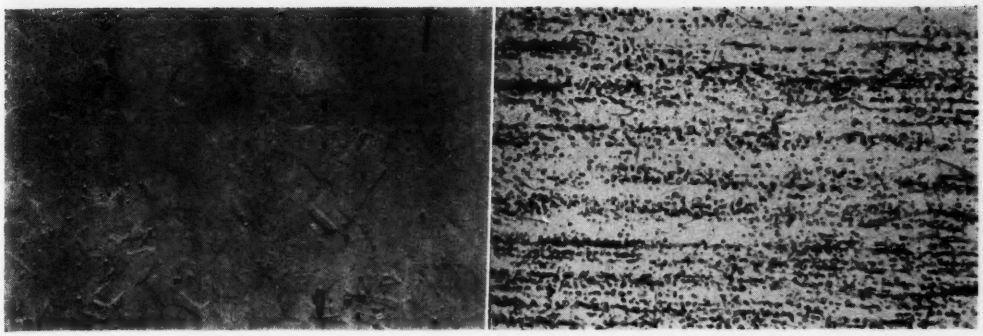
A definite relationship was found to exists between the proportional limits and the tensile strengths of the alloys. The slope of proportional limit versus tensile strength is almost 45°, so a definite unvarying ratio exists between the two values. It was found that the proportional limit was about 2/3 of the tensile strength. This relationship is shown in Fig. 4.

An excellent correlation was found to exist between the proportional limits of the alloys determined in the stiffness tests and the diamond pyramid hardnesses of the alloys. The only alloy consistently deviating was Alloy H, which ran high. A plot of these values, together with a line fitted to the data by a least squares analysis, is shown in Fig. 5.

Since a definite correlation was found to exist between diamond pyramid hardness and tensile strength, as well as diamond pyramid hardness and bending proportional limit, there should be a similar relationship between tensile strength and bending proportional limit. This was found to be true, as shown by the values plotted in Fig. 6.

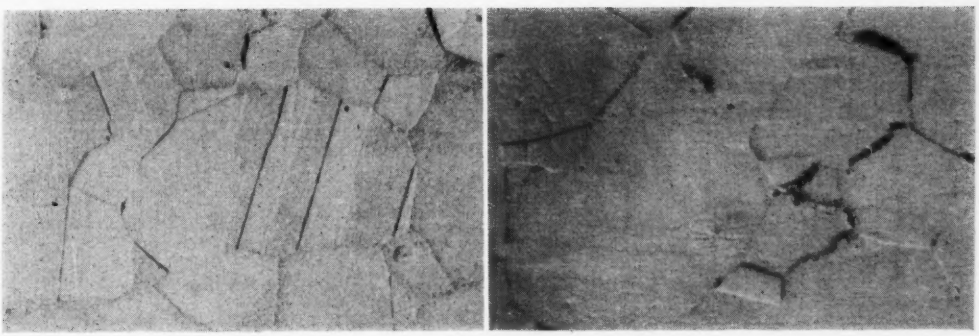
Microstructure.—Analysis of the photomicrographs indicates that the different alloys can be grouped into three broad classes including eight alloys, and four additional classes for the remaining four alloys. The three broad classifications are:

1. Small equi-axed grains; a sparse uniformly scattered precipitate, and occasional short stringers (Alloys A, D, G).



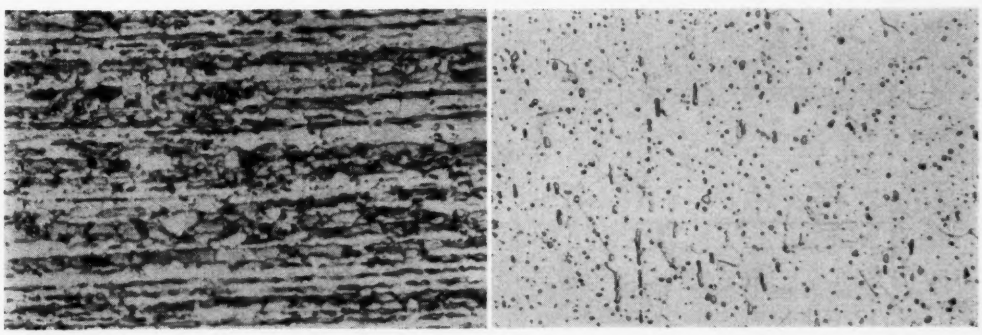
A, Alloy A—Hard (Alloys D and G are similar)

B, Alloy B—Hard (Alloy E is similar)



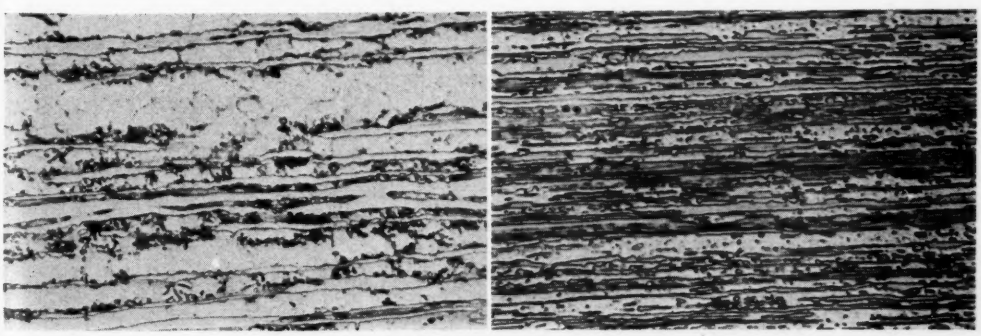
C, Alloy F—Soft (Alloys C and K are similar)

CC, Alloy F—Hard (Alloys C and K are similar to Alloy F)



D, Alloy H—Hard

E, Alloy I—Hard



F, Alloy J—Soft

G, Alloy L—Hard

Fig. 2. — Typical microstructures of dental gold wires investigated. Ammonium persulfate-potassium cyanide etch. 1000×

2. Small slightly elongated grains; dense, banded precipitate (Alloys B, E).

3. Medium to large equi-axed grains. Twinning. No precipitate in soft and limited to grain boundary in hard alloys (Alloys C, F, K).

The remaining four alloys have distinctive microstructures which cannot be grouped together. The typical microstructures of these alloys are:

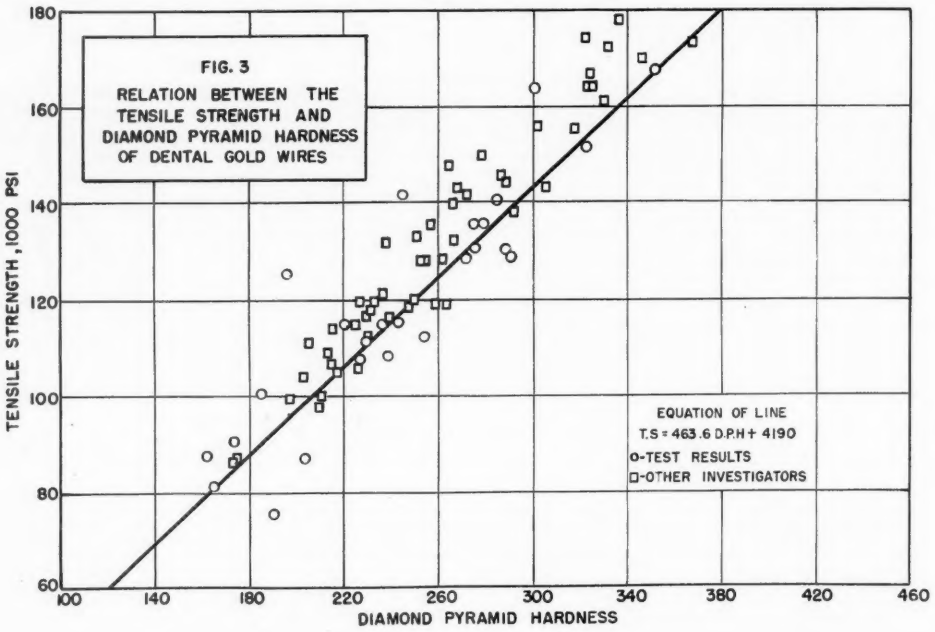


Fig. 3.

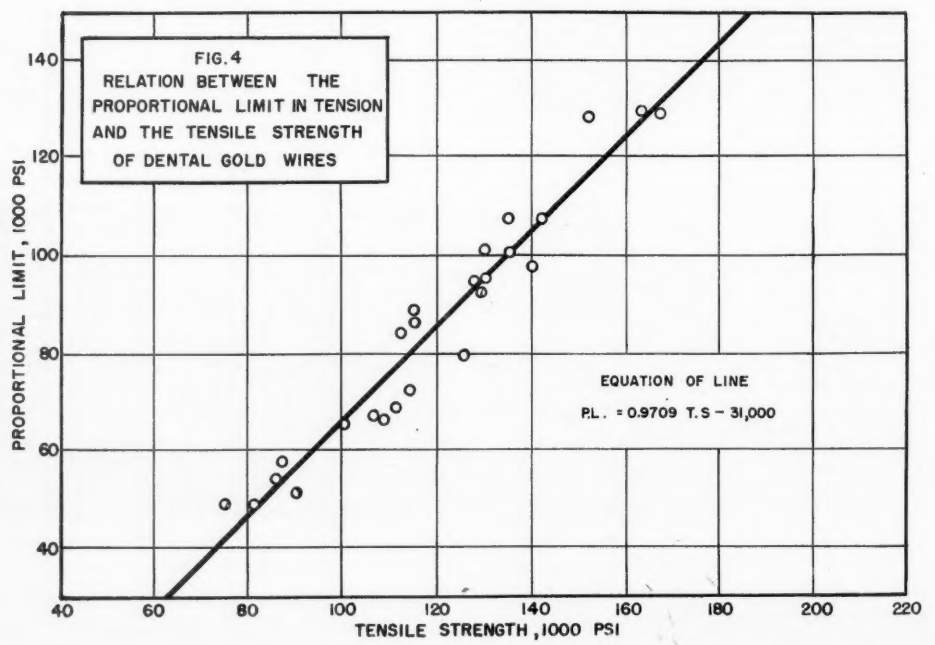


Fig. 4.

Alloy H. Small equi-axed grains seemingly connected together to form longitudinal chains; the general appearance is one of stringers of varying length embedded in a plain matrix; the pattern is very dense.

Alloy I. Small to medium equi-axed grains; many short, disconnected stringers in the drawing direction; a fine precipitate distributed in a random pattern throughout the specimen.

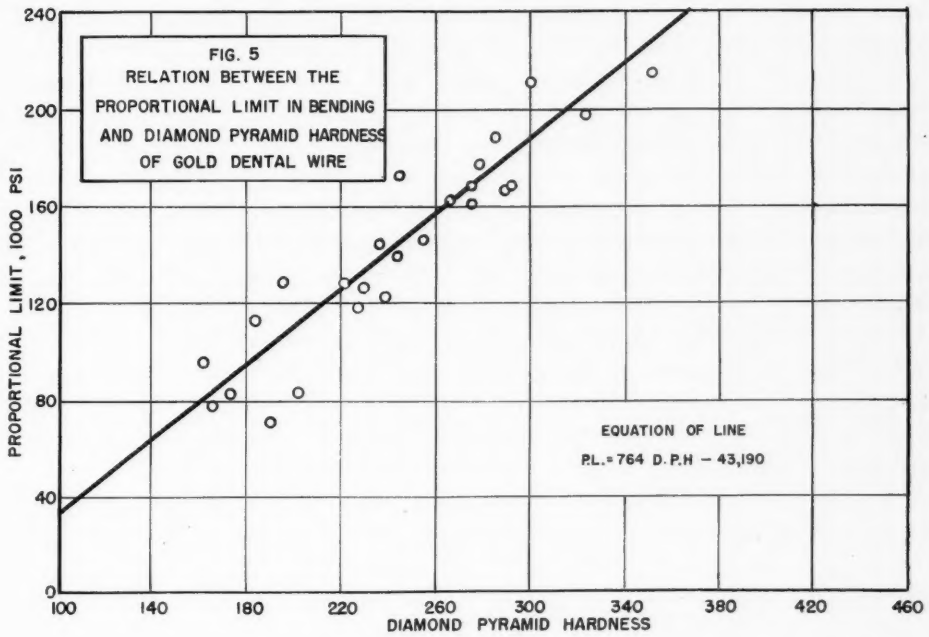


Fig. 5.

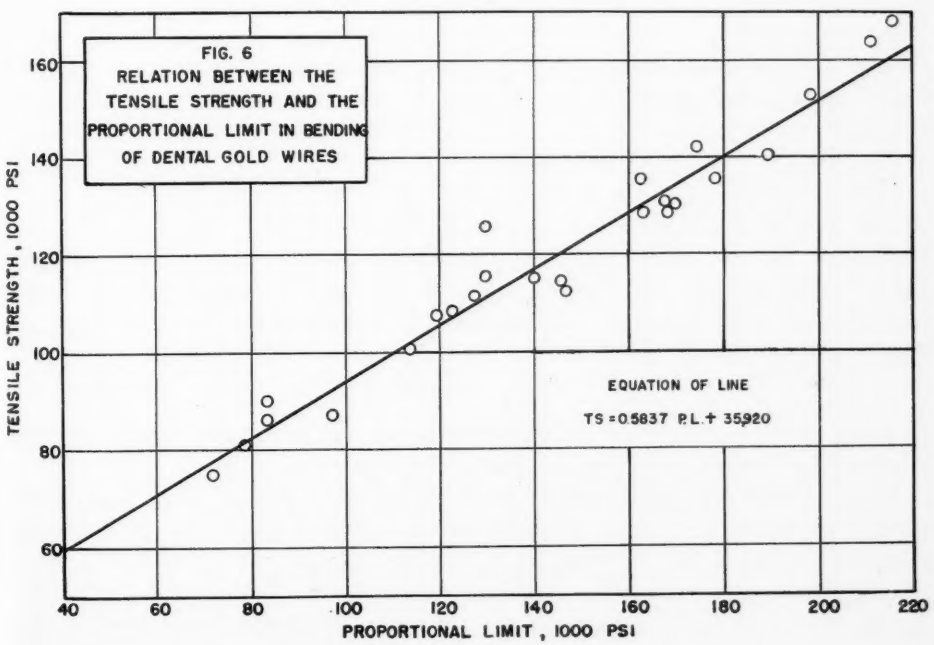


Fig. 6.

Alloy J. Pronounced banded structure. Three types of bands are present; the matrix material contains medium-sized, slightly elongated grains; there are long violet stringers extending the length of the specimen. Narrow bands of dense, fine precipitate surround the stringers.

Alloy L. Extremely small grain size; precipitate is very dense and is distributed along the longitudinal axis of the wire; there are occasional narrow bands containing no precipitate.

It is interesting to note that there is a definite relationship between the chemical composition and the microstructure. A comparison of the chemical composition of the alloys falling in classification 1 shows that gold, platinum group, and minor alloy content are almost the same, and silver and copper contents show a maximum variation of less than 2 per cent by weight. In classification 2 this relationship is even more pronounced; the maximum difference between the amounts of any one element in two alloys is only 0.5 per cent. A wider spread in alloy content is noted in classification 3 but it is interesting to note that the sum of the gold plus copper varies less than 2 per cent, and the platinum group content is also comparable.

The similarity of microstructure is the soft (solution-treated) and the hard (aged) states in the case of Alloys C, F, and K supports the hypothesis of an order-disorder mechanism. The increase in the precipitate in the case of Alloys B and E and to a limited extent Alloys A, D, and G, indicates that in part the hardening of these alloys may be due to a precipitation type reaction.

Effect of Alloys.—The most noticeable effect accompanying the addition of platinum group metals is the pronounced grain refinement. At high (up to 20 per cent) concentrations the grain size was uniformly small and apparently unaffected by heat treatments such as were used in these experiments. The decrease in concentration of the platinum group resulted in a larger grain size and an alloy much more susceptible to heat treatment from the temperatures used in this study. Even moderate overheating caused excessive grain growth in some cases.

The precipitate observed at the grain boundaries of Alloy F after aging is believed to be caused by the palladium present. Wise and Eash[1] note that palladium causes such a precipitate.

The structure obtained in Alloys H, I, J, and L are believed to be due to the pronounced variation in composition.

No definite relationship was established by this study between chemical composition and mechanical properties or microstructure and mechanical properties. While the hardness values or tensile strengths of alloys having similar composition or microstructure are similar, the spread is too great to permit a definite comparison.

CONCLUSIONS

1. A definite correlation exists between the hardness and tensile strength of wrought gold alloys of varying chemical composition.

2. A similar correlation exists between the proportional limits and tensile strengths of alloys which can be expressed as a ratio of the one to the other, for example, proportional limit equals ⅔ tensile strength.

3. A linear relationship exists between the proportional limit in bending and diamond pyramid hardness. A similar relationship exists between proportional limit in bending and ultimate tensile strength.

4. The Vickers hardness tester equipped with a 10-kg. load and a 136° diamond point is satisfactory and practical for determining the hardness of small wires.

5. Platinum and palladium reduce the grain size markedly and render the alloys less sensitive to the heat treatment used in this study.

6. A definite correlation was found to exist between microstructure and chemical composition of alloys from different manufacturers.

7. The hardness-tensile strength data determined experimentally were found to be comparable to previous work of other investigators substantiating the definite correlation obtained.

8. Little change was observed on comparing the microstructures of most alloys in the solution-treated (softened) and age-hardened states at either 100 or 1000 diameters' magnification. This would support the order-disorder reaction as the most important hardening mechanism in these alloys.

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HARDNESS AND FLOW PROPERTIES OF GYPSUM MATERIALS*

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THE use of gypsum type materials in the field of dentistry is of such a nature that present and past studies on physical properties appear indadequate to predict, accurately, their behavior under practical conditions. This report is concerned with those properties which more ably define these materials when used in dental techniques and processes.

Unfortunately, the property of hardness, which will be discussed first, is not derived from a study of simple homogeneous states of stress such as pure tension, compression, or shear. As a result, there are different interpretations of this important property of matter. The one which will be discussed in this paper is the manifestation of properties of a material which resists penetration from a small object. These manifestations in the form of impressed areas or depth of peneration lend themselves to measurement and, as a consequence, materials can be compared as to their penetration resistance. Care must be exercised with respect to the evaluation of results, in that different types of materials exhibit paradoxical behavior, that is, rubber may indicate a higher hardness number than steel. The reason for this is that most hardness tests involve the recovery properties of the materials being tested. Those materials having a high degree of recovery exhibit higher hardness numbers than are justified. Also, correlations to other properties such as wear resistance must be adequately analyzed, if an analysis is at all possible.

The Rockwell Superficial Hardness Tester was chosen as the testing device, since its features encompass the requirements necessary for testing these gypsum materials. For these relatively soft gypsum materials, a large penetrator and a light load are necessary to obtain a scale reading. This machine applies a minor load of 3 kg. A one-half inch steel ball penetrator was chosen with a 15 kg. major load as the combination most practical to the gypsum materials tested. This combination yields the standard Rockwell Hardness Scale 15Y. For either shallow or deep penetrations, that is, readings greater than 100 or less than 0, spherical penetrators become geometrically supersensitive; and errors and effects of heterogeneity of the specimen become unduly magnified. Therefore, for the softer states of plaster and plaster containing starch materials, the major load was dropped to 7.5 kg. and the resulting values empirically referred to the 15 kg. major load condition. The negative hardness values which appear later are, therefore, not hardness readings taken directly from the Tester, but those which have been extrapolated from the 7.5 kg. major load condition.

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Specimens were prepared in an exacting fashion to eliminate undersirable variables. The powder was weighed carefully and distilled water was measured using a burette. The water was poured into a damp-dry rubber mixing bowl after which the powder was added through a sieve. Thirty seconds after the powder was added, the mix was spatulated for 1 minute and evacuated for 15 seconds. The mix was then vibrated into molds formed by 1-16 inch wall tubing having an inside diameter of 1⅝ inches and cut to a length of one-half inch. Glass plates were placed at each end of the mold to insure parallel faces as well as a good surface. The specimens in the molds are shown in Fig. 1.

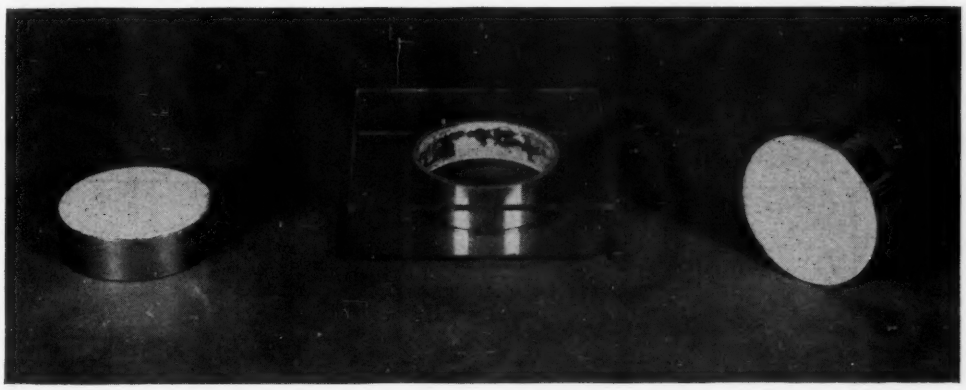

Fig. 1. — Mold for hardness sample.

The proportions of water and powder to be mixed were determined by a slump type consistency test similar to that outlined in the A.D.A. Specification II for Dental Inlay Casting Investment. This consists of filling a cylindrical mold 2 inches long and 1⅜ inches inside diameter. The mold was placed on a dry glass plate and lifted 2 minutes after mix, thereby allowing the material to spread or slump over the plate. The hydrocal was mixed at a water/powder ratio of 30/100, as usually recommended, and its slump recorded. For the same degree of slump, both the plaster and plaster containing starch materials had to be mixed at 50/100 and the improved stones at 23/100.

As is already known, these gypsum materials are mixed to include water in excess of that needed for exact chemical combination. As a result, the excess water, which does not combine, exists in small voids throughout the material. In the presence of a drying atmosphere, the free water diffuses to the surface and evaporates as the age of the specimen increases. Since the rate of water loss depends on the surrounding atmosphere and the specimen age, keeping all other factors constant, it was concluded that a calculation of percentage excess water present would combine these two variables and more precisely define the condition of the gypsum material. This was done, and throughout this paper reference will be made to excess water present in the specimen at the time of test as a variable.

As this excess water is lost to the storage atmosphere, the properties of these gypsum compounds become more favorable; and at the point where all

excess water has been dissipated, the material is in an optimum physical condition. The data in Fig. 2 illustrate this behavior. Immediately after final set, the gypsum material is relatively weak and increases in hardness to approximately 68 when the excess water present is about 7 per cent. This point was reached in about 1 hour. This early increase in properties appears to be due to further hydration after the final set. The final set as determined by the Gilmore Needle is a relatively arbitrary point and does not necessarily define the end point of the reaction. Sodeau and Gibson[1] have shown that the "hydration" time may be 2 or 3 times the "final set" time. From this point on, the hardness of the material is fairly constant until most of the excess water is lost to the surrounding atmosphere. When this water is lost, a large increase in hardness was experienced.

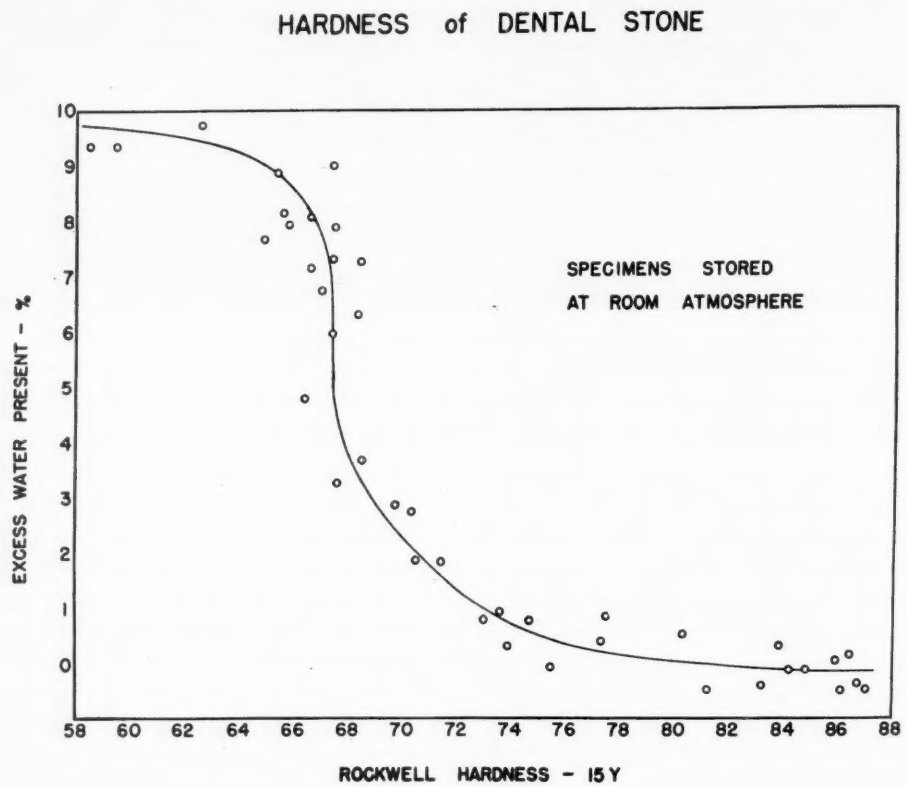

Fig. 2.

At the point of practically no existing excess water, the material is at its optimum condition of 86 RHN.* At an average laboratory atmosphere of 23 per cent relative humidity and 74°F. temperature, this end point was reached in about 2 weeks. There does not appear to be any adequate explanation for this sudden increase in properties when the excess water has been liberated. It is hoped, though, that further studies will reveal more of the fundamental reasons for this behavior.

*RHN=Rockwell Hardness Number.

Since it is customary to think in terms of compressive strength for gypsum materials, work was done on this physical property in conjunction with the hardness tests conducted. Similar behavior was observed as a result of varying the excess water present. As a consequence, a correlation was established between hardness and ultimate compressive strength. Theoretically, a good correlation should exist since there is little recovery in these gypsum materials and the hardness tests involve mostly plastic deformation. This correlation is shown in Fig. 3. The data for this curve were plotted from the curve in Fig. 2 and from a similar curve of compressive strength of dental stone versus excess water present. Since it is the surface hardness that is measured and since compressive strength indicates the condition of the entire specimen, it was found that the hardness increases faster than the compressive strength. This is not an odd observation, as the surface being drier than the center is a necessary condition for the diffusion process. In practice, since these materials rarely fracture or break, compressive strength appears undesirable as a criterion for material condition. On the other hand, working with the surface constantly in dentistry firmly establishes hardness as a most important property.

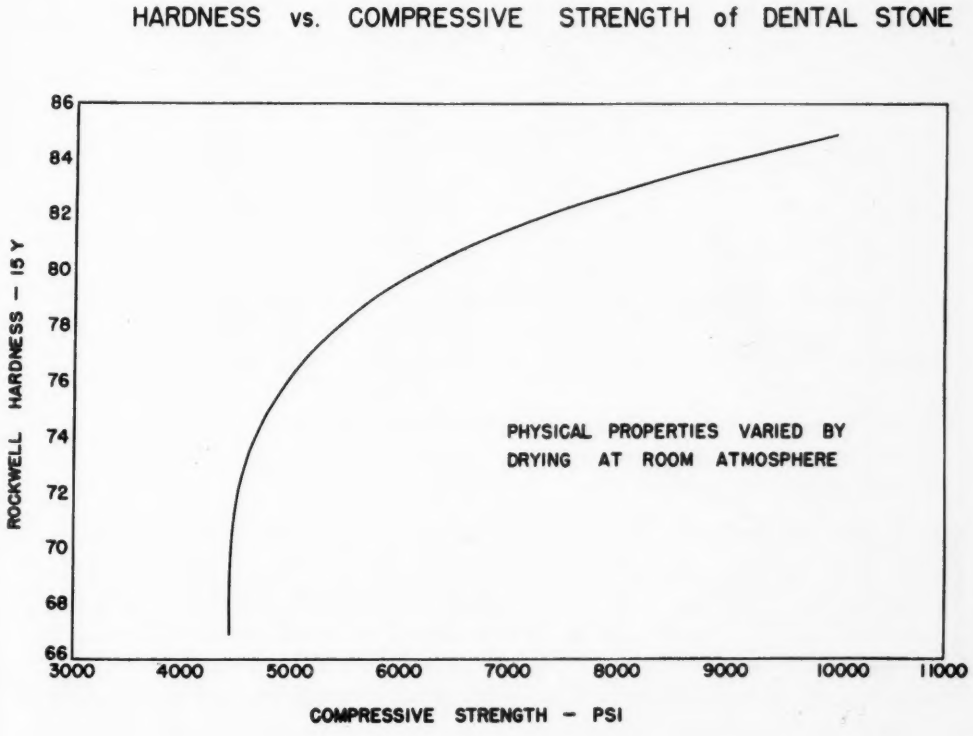

Fig. 3.

The data in Fig. 4 illustrate the behavior of four different types of gypsum compounds which include plaster, plaster containing starch, stone, and improved stone in the important ranges of their practical applications and increase in prop-

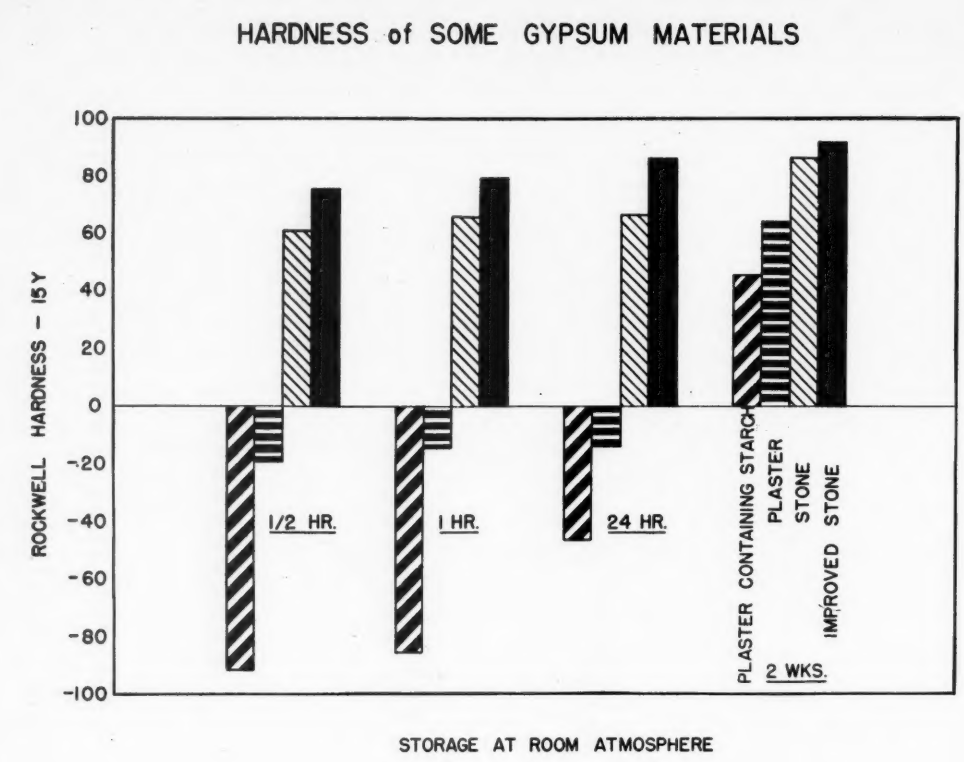
HARDNESS of SOME GYPSUM MATERIALS
ROCKWELL HARDNESS - 15 Y
100
80
60
40
20
0
-20
-40
-60
-80
-100
1/2 HR.
1 HR.
24 HR.
2 WKS.
PLASTER CONTAINING STARCH
PLASTER
STONE
IMPROVED STONE
STORAGE AT ROOM ATMOSPHERE

Fig. 4.

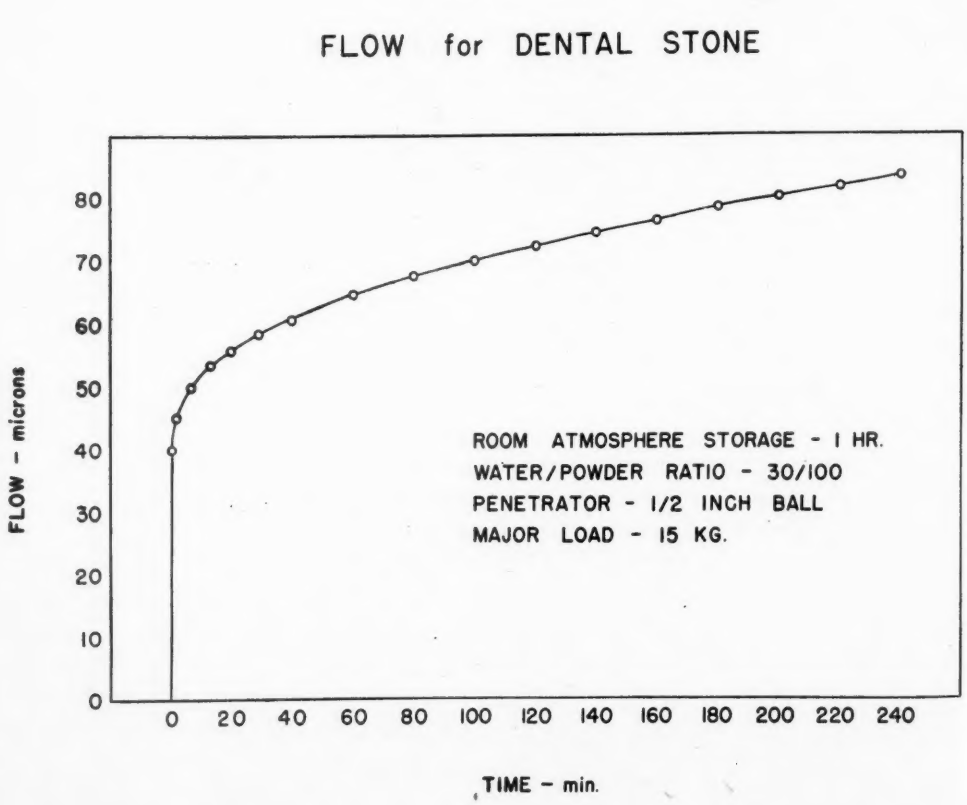
FLOW for DENTAL STONE
FLOW - microns
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
220
240
TIME - min.
ROOM ATMOSPHERE STORAGE - 1 HR.
WATER/POWDER RATIO - 30/100
PENETRATOR - 1/2 INCH BALL
MAJOR LOAD - 15 KG.

Fig. 5.

erties. Although different manufacturers' products were tested, only one of each type of gypsum material has been reported so as not to becloud the fundamental ideas of this paper. It is sufficient to say that although some products may be slightly stronger or weaker than others, the general behavior as outlined in the results of this paper holds for all tested.

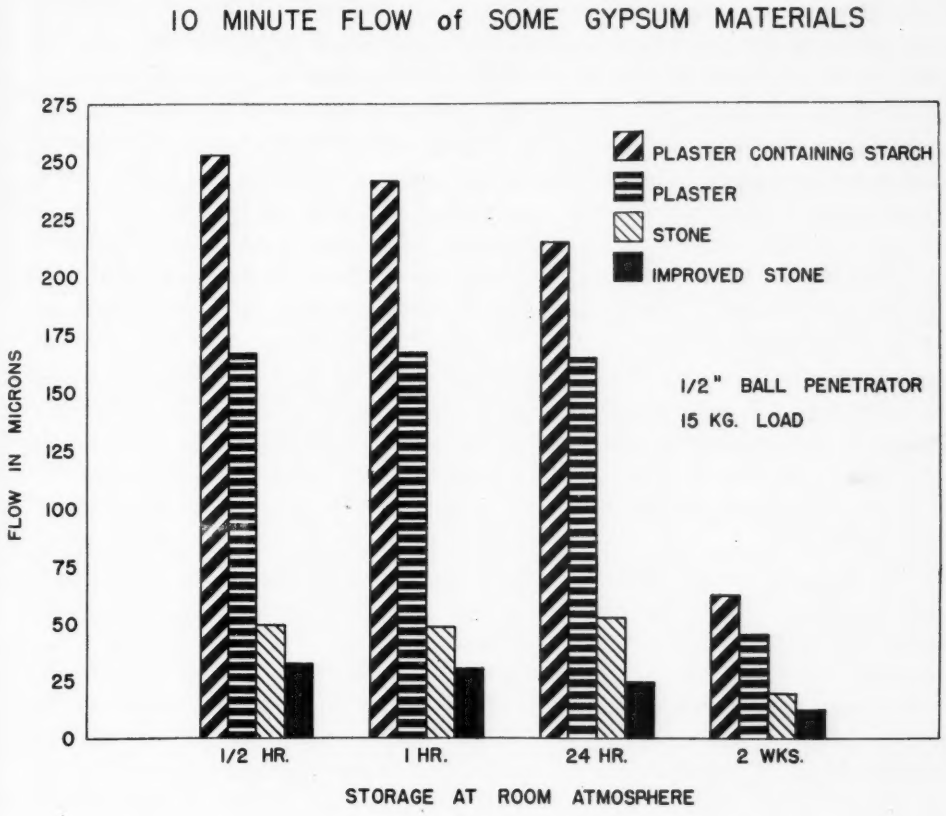

Fig. 6.

The drying condition of the atmosphere determines the rate of water loss and, if the specimens were placed in a drying oven, the optimum physical properties of these materials might be achieved in a shorter period of time. As a consequence, tests were run storing the specimens at different temperatures and for different lengths of time. A temperature of 90°C. was finally chosen as the drying temperature and it was found that about 3 hours were necessary to bring dental stones and the improved stones to their best properties, while about 5 hours were necessary for plaster and over 5 hours for the plaster containing starch materials. It should be noted that these tests were run on hardness specimens and that larger amounts of material will take longer drying periods. The tests run indicate that about 36 hours is necessary to bring the large bulk of material used in a flask to an optimum condition (the improved stone was

considered here). These gypsum materials are essentially the dihydrate of $CaSO_4$ which results from the physiochemical reaction of the hemihydrate of $CaSO_4$ and water. Care must be exercised, therefore, in that prolonged heating will cause the surface to go back to a subhydrate of $CaSO_4$ (most likely the hemihydrate) and an accompanying contraction will take place. In addition, the subhydrate is weaker than the dihydrate and the end result may be less advantageous than the condition of the material immediately after final set. Work is continuing on this phase of the project with reference to attaining these optimum physical properties as expeditiously and as accurately as is possible.

In addition to these hardness studies, the flow behavior of gypsum materials was studied. The flow, as determined, is that which occurs when the material is impressed by a small indentor. Expressed more specifically, if a load were to be applied to the material through an indentor, the indentor would continue to penetrate into the specimen as time increases. The dial gauge on the Rockwell Superficial Tester reads indentation directly in microns, thereby facilitating the study of this property. The "spring" of the machine must be compensated for, since its effect occurs in the same direction as the indentation. All data, as given, are in the corrected form. The data in Fig. 5 show the flow behavior of a typical dental stone over a 4-hour period. As can be seen, the flow at 10 minutes is 52 microns while at 4 hours, or 240 minutes, it is 83 microns. In other words, as the time increases 24 times, the flow increases only 1.6 times. This indicates the rather critical flow behavior at early time intervals with respect to the overall flow behavior.

One important application of these flow properties occurs in the analysis of the complete denture technique. In this usage, the teeth act upon the investing material essentially in the same manner as the ball indentor acts in the flow tests. The indentors are the teeth and the major load is the force applied by the resin during the packing and curing process. From a study of the complete denture technique using the simple flask, it would appear that most of the movement would occur during trial packing, since the pressures exerted by the resin seem higher than any subsequent pressure due to the curing process, although further studies might prove otherwise. This trial packing usually takes place over a period of 10 minutes. The data in Fig. 6 illustrate the 10-minute flow values for the materials studied in the important ranges of their practical application and increase in properties.

Further studies on the practical application of these flow properties to the complete denture technique have been undertaken. To date, however, no attempt has been made to do a rigorously analytical analysis of how far the teeth might be impressed into the investing medium. Some interesting information, however, was presented by Steck[2] in her work on vertical dimension. It would seem that using a given excessive flasking pressure, the vertical dimensional shift was 0.012 inch for stone and 0.008 inch for the improved stones. The importance of this information with respect to the flow data in Fig. 6 is that there is a considerable change in vertical dimension for a flow difference of 18 microns. These 18 microns are the difference between the value of stone (48 microns) and the

value of improved stone (30 microns), stored for 1 hour at room atmosphere. This would appear to substantiate the sensitivity of these tests with respect to their practical application.

CONCLUSIONS

1. The practical application of gypsum materials used in dentistry reflects the importance of surface property determinations.

2. The Rockwell Superficial Testing Machine is an instrument capable of measuring these surface properties. The usage of a one-half inch ball and a 15 kg. major load satisfies most ranges of material condition. For the softer states, 7.5 kg. major load may be used and the values extrapolated to the 15Y scale.

3. Gypsum materials experience an increase in properties while stored in a drying atmosphere and reach their optimum condition after 2 weeks' storage when the average laboratory humidity and temperature are as indicated. These optimum properties referred to a flask bulk can be achieved by heating in a drying oven at 90°C. for about 36 hours, for the improved stones. This procedure might appear impractical in view of the demands of present-day dentistry. However, an attempt should be made to refrain from using these materials before the hydration time, which occurs at about 1 hour after mix. At this point, which corresponds to a value of 68 RHN from Fig. 2, the material is beyond the relatively soft range afforded by incomplete hydration.

4. Compressive strength can be correlated to hardness, thus dispensing with a time-consuming test which, in the first place, is not applicable to the practical usage of these materials.

5. Flow beneath a small indentor is a good test for resistance to penetration properties and a good correlation appears to exist to the problem of tooth movement in the complete denture technique.

The original idea of using the Rockwell Hardness Machine for hardness and flow properties of gypsum materials was conceived by W. T. Sweeney, now associated with the National Bureau of Standards.

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THE LABORATORY'S ROLE IN SUCCESSFUL FULL DENTURES

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THERE is not much contact between dentists and laboratory technicians because of the increased size of dental laboratories, technical developments, and the modern dentist's preoccupation with operative instead of laboratory procedures. One way to improve this situation is to establish a closer tie between the laboratory craft and the dental profession, as groups instead of individuals. Recent rumblings indicate that this improvement is under way, and many dental societies are beginning to follow in the footsteps of the Southern California State Dental Association, which puts on semiannual clinics for the laboratory industry.

There are two principal areas in which closer cooperation between dentist and laboratory will result in improvement in the prosthetic service. First, the dentist observes the physiologic or biomechanic effects of dental appliances. He has the case histories as a source of information. Some of this information must be made available to the laboratory technician if the latter is to take an interest in anything but the fit, strength, and appearance of his appliances. Second, the dentist continually delegates to the laboratory technician certain procedures which should be performed in the dental office. The laboratory cannot ask the individual dentist to stop doing this, because such action would jeopardize his business relationships. Group cooperation should allow an exchange of views on a broad scale without this risk.

The present loose relationship between the dentist and the technician makes it difficult for either to improve his technique materially. For example, if dentists continue to request that technicians post dam and relieve upper dentures, without giving them adequate information, the technicians cannot consistently produce excellent dentures. And on the other hand, if the technicians modify peripheral borders of dentures to suit their fancy, the dentists cannot consistently get good results. This article is confined to one side of the problem—laboratory practices which detrimentally affect full dentures.

Faults in full denture construction which can be laid at the door of the dental laboratory include six broad groups. They are: faulty base areas, faulty vertical dimension, faulty occlusion, faulty gross construction, faulty phonetics, and faulty esthetics.

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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FAULTY BASE AREAS

Faults in base areas result from improper handling of impressions, underextension, overextension, improper post dams and reliefs, and warpage due to dimensional changes in acrylic during curing.

Improper Handling of Impressions.—The increasingly popular alginate (irreversible hydrocolloid) impression takes on dimensional changes when exposed to air for fifteen minutes, or when immersed in water for more than two hours. Casts should be poured rapidly if they are to be correct. The Bureau of Standards states that more than twelve hours' immersion in water will alter the shape of reversible hydrocolloid impressions.

Underextension.—The most common and most costly underextension is on the posterior one-third of the lower denture. Lower impressions determine the base areas of full lower dentures. But the technician frequently has some opportunity to use his own judgment in regard to extension, because he makes the impression trays.

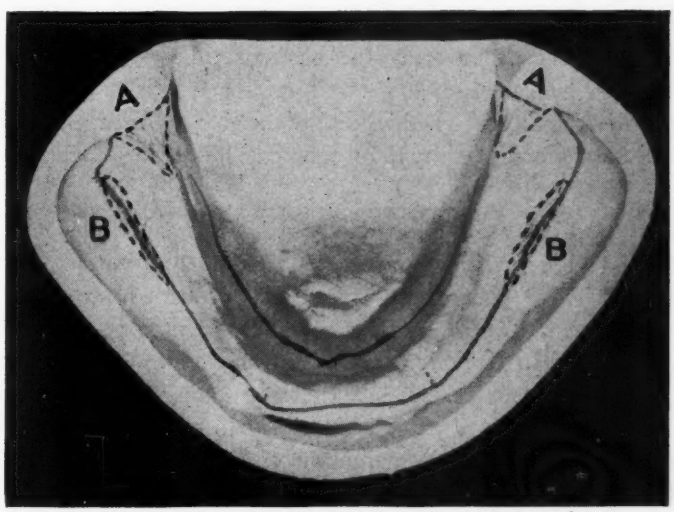

Fig. 1.

Fisher[1] recommends the making of a border outline through the use of two landmarks. He draws a line straight across the back of the pear-shaped retromolar pad (Fig. 1, *A*). Another line (not shown) is drawn straight down the crest of the ridge. The angle formed by the two lines is bisected and a line is dropped laterally to the external oblique ridge (Fig. 1, *B*). The outline of the lateral flange is completed by following the direction of the external oblique ridge forward to a line which is dropped from the cuspid area of the alveolar crest to the line where the mucobuccal fold begins to leave the ridge to form the sulcus and attach to the cheek. The use of these landmarks affords broad snowshoe coverage so essential to a proper base area for tailored impression trays and full dentures.

A large mouth takes a large denture, and a small mouth, a small denture, but there should be no such things as "large" or "small" denture bases insofar as they

reflect ridge conditions. We should not make a denture base small simply because the ridge is flat. All dentures should cover the top of the body of the mandible. The bodies of mandibles are similar in outline—as similar as the shapes of hands or feet. The height of the ridge may vary, but the coverage should be the same in all cases.

The attachment of the buccinator muscle does not control the extension of the buccal flange because much of the lateral extent of the buccal flange rests on the attachment of the buccinator muscle.

Many technicians feel that it is their duty to trim the buccal flanges of lower dentures short of the reflection, "so that the denture won't make the patient's mouth sore." In doing so, they cut off the most important part of the dentures—part of the buccal flange.

Another very common reason for the underextension of lower dentures is the lack of space between the tuberosity above and the retromolar pad below. Dentures should never be cut short in such cases, nor should the vertical dimension be opened on the articulator, in the laboratory. If some space exists, 28 gauge gold casting may be used to cover the areas where interference exists. The castings are just little caps covering the pads or tuberosities, and are attached to the denture base by retention loops. If no space exists, the case should be returned to the dentist to see whether or not he desires to open the vertical dimension (a questionable procedure), or whether he wishes to surgically reduce the tuberosity.

Faulty Post Dams and Reliefs.—Faulty post dams and relief areas are common because the technician is willing to assume a responsibility which he can in no way fulfill. These procedures cannot be performed satisfactorily without reference to the patient. The technician should take no responsibility for upper case failures if he is called upon to post dam and relieve cases. Dentists may post dam and mark casts for relief when they are taking the centric jaw relationship. The relief should always extend anteriorly to cover the anterior (incisive) papilla, which is the little bump at the midline on the crest of the upper ridge.

Warpage and Shrinkage.—Shrinkage occurs in the palates of upper dentures; the minimum discrepancy is from 0.25 to 0.5 mm. The shrinkage is greater if the curing does not allow a slow rise in the temperature of the curing bath. An hour should be consumed as the temperature of the bath rises from room temperature to 158° F. The case should then be boiled for 30 minutes to complete polymerization. To minimize warpage when recuring for repairs, etc., the case must not be boiled; instead, temperature must be maintained at 158° F. for several hours to effect a complete cure.

FAULTY VERTICAL DIMENSION

Faulty vertical dimension is a common denture fault. It is axiomatic that the technician should never open the incisal guide pin on an articulator to make space for teeth, to make space for the denture base, or for any other reason. There is nothing which will cause a greater multitude of complaints from the patient than

too great a vertical dimension. The patient has a definite mandibular rest position which never varies and which is controlled by the length and tone of the muscles attached to the mandible. When the patient is at rest, his teeth should be separated. This space between the occlusal surfaces of the upper and lower teeth is called the freeway space. If the patient's teeth contact when he is at rest he cannot wear the dentures. When the technician opens the incisal guide pin on an articulator, he is infringing upon the freeway space. He is dooming the case to failure.

FAULTY OCCLUSION

Faulty occlusion comes from a myraid of sources. Setups which are not balanced in lateral and protrusive relationships, unstable baseplates, careless mounting of casts, the use of mechanically imperfect articulators, flaming wax after a setup, chilling waxed-up cases in cold water, ill-fitting flasks, and many other factors contribute to occlusal faults.

Anterior teeth should never be in contact in centric occlusion and should never interfere in functional movements. The contact of anterior teeth in centric occlusion causes many soft and flabby anterior ridges. The horizontal overjet should always equal the vertical overbite. Jordan[2] makes the statement that at least 2 mm. of horizontal overjet is desirable. This is far different from the tightly locked anterior occlusion so commonly in evidence in laboratory setups. The technician should endeavor to eliminate vertical overbite and work to a flat incisal guidance as much as possible. This holds true in the arrangement of teeth for immediate dentures also.

Failure to Close Flasks.—Flasks should be closed into a metal-to-metal contact, and should be given final closure after a test pack shows no flash of acrylic. The practice of adding a pea-sized ball of acrylic on final closure, as advocated by some manufacturers, has been proved fallacious by the United States Bureau of Standards.

One-half millimeter of flash at the distal of the denture opens the occlusion 1 mm. anteriorly, because the anterior teeth are further from the opening axis of the jaw. One-half millimeter flash on a full upper and on a full lower doubles this error. The flash opens the occlusion on a case in a vertical direction, while the mandible moves downward and backward as it opens. Hence, the flash produces a premature contact of the anterior slopes of the cusps of lower teeth and the posterior slopes of the cusps of the upper teeth. This means that centric occlusion is made incorrect. This causes pounded ridges and uncomfortable patients, adjustments for the dentist, and trouble and "no charge" remakes for the laboratory man.

Occlusal Adjustments.—This should be done before the dentures are removed from the casts, unless it is the dentist's custom to remount full dentures from the patient's mouth for occlusal adjustment, or if he does not have some other adequate technique for regaining proper occlusion. The laboratory should remount the cured dentures on the original articulator mounting. Corrections can then be made in the occlusion.

Occlusal correction should be accomplished by selective spot grinding and not by milling. Interfering cusps can be reduced individually by spot grinding, but by milling, both opposing surfaces are reduced, and this double reduction may take an important tooth surface out of occlusion when it is in some other position during chewing movements. Grooves and sulci can be deepened, when it is desirable to maintain or increase cusp height, instead of reducing the height of cusps.

The correction of occlusion should be a careful laboratory process for those dentists who desire to have correction performed in the laboratory. It is a process which the dentist should be willing to pay for, because it is time-consuming and important.

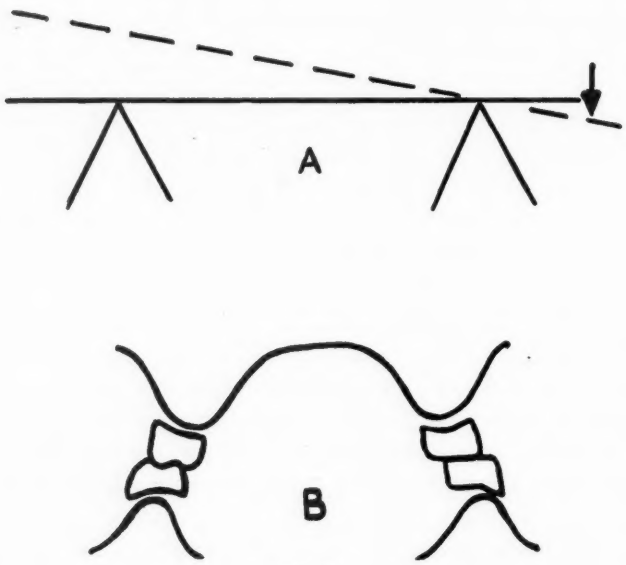

Fig. 2.

FAULTY GROSS CONSTRUCTION

Faults in gross construction include mistakes in tooth size and position, and faults in contours and materials.

Tooth Size.—Authors of textbooks say that posterior teeth should be chosen by measuring from the distal of the lower cuspid to the anterior point of the retromolar pad, a measurement of 30 or 32 mm. indicating mold 30 or 32 posterior teeth. In the case of excellent ridges this may be true. However, when ridge relationships are poor and when ridges are not large, a smaller tooth is indicated to decrease the load. Except in the case of big, strong ridges, the tendency should be to use much smaller teeth, regardless of the available space. Large dentures with small teeth do not look attractive in the laboratory, but in the mouth they are kinder to supporting tissue.

Tooth Position.—Fig. 2, *A* shows a plank across two sawhorses. Pressure on the plank, outside the sawhorses, tends to tilt the plank, but pressure on the plank between the sawhorses distributes the load on both sawhorses. Similarly, teeth set buccal to the ridge allow one ridge to carry the load and cause pounding of the loaded ridge as the denture tilts. More teeth should be set in cross-bite position (Fig. 2,*B*) to get the load inside the ridge and insure equitable distribution of loads across the arch. Cuspless teeth allow more latitude in setup and in function in cross-bite cases. A cuspless tooth set in cross-bite position also tends to cut down the food table in the final phase of the chewing cycle, and this decreases the load on the ridge. The technician may get more tongue room in the lower bicuspid region, without setting the actual occluding surface of these lower bicuspids outside the ridge, by setting the teeth in cross-bite relation. This additional tongue room in the bicuspid region allows the patient to carry his tongue well forward and maintain a very important seal against the lingual flange in the lower incisor area.

Tooth Type.—Although the arguments pro and con as to the merits of various types of teeth go on unabated, there are two points which should be kept in mind. The shearing efficiency of a porcelain tooth is rated as 30 per cent greater than that of an acrylic tooth. The anatomic tooth is conceded to be more efficient than the cuspless tooth. Poor ridges are easily recognized in the laboratory. Their adverse leverages can and should be compensated for through the use of the most efficient teeth.

Flange Contour.—A common error in flange contour is in the shaping of the lingual surface of the lingual flange of the lower denture. It should never be the least bit convex, because such a shape allows the tongue to dislodge the denture. The lingual surface of the lingual flange should be flat or slightly concave for maximum stability.

Frequently the buccal sulcus is very broad on upper casts, particularly in the area lateral to the tuberosity. The broad roll, sometimes almost as big as a lead pencil, should be maintained in the finished denture, because that contour is needed for a seal if a large sulcus exists. The peripheral roll of the impression should always be maintained in the finished denture.

Anterior Thrusts.—A rocker-shaped lower ridge, having a sharp ascent in the posterior region, is an indication for the elimination of occlusion in the region of the second molar. Pressure on the second molar tends to scoot the denture down the inclined plane, forcing it forward. Prosthodontists frequently leave second molars off dentures, or at least omit the upper second molar, and use the lower for balancing purposes only. Technicians seldom omit teeth, even when indicated.

Metal Bases.—The cast palate too often is ordered or omitted for purely financial reasons; usually it is indifferently employed, and its value is underestimated. The cast palate provides better adaptation to the mouth than does acrylic, because the latter shrinks away from the palatal portion of the cast as a result of dimensional changes in curing. Cast bases are better for the gagging patient and for those who present problems of retention.

PHONETICS AND ESTHETICS

Phonetics and esthetics are radically affected by the positioning of the anterior teeth. Success depends upon the ability of the technician to maintain the dentist's measurements as indicated upon the wax rims. The removal of large portions or all of the upper wax rim prior to setting up teeth undoes a great deal of painstaking work.

Upper Anteriors.—One of the most common laboratory errors is the tendency to set upper anterior teeth on the ridge regardless of the contouring of the wax rim. Two common errors are made in attempting to overcome excessive horizontal overjet. The upper anteriors are set back too far on the upper ridge, or the lower anteriors are set forward off the ridge. Both of these are fatal errors. For proper esthetics and phonetics, the upper anterior teeth must be set out where the natural teeth were, regardless of the relationship to the ridge. This was nicely illustrated by a patient with faulty dentures in which the position of the anterior teeth appeared to be the one gross fault. He reported that his wife, a deaf woman who was well trained in lip reading, could not read his lips with any success. His lips and tongue were not functioning normally, even though he spoke clearly. When the new dentures were constructed, his wife was able to read his lips. This is a striking example of the importance of building dentures to the desired contours, as registered in wax by the dentist.

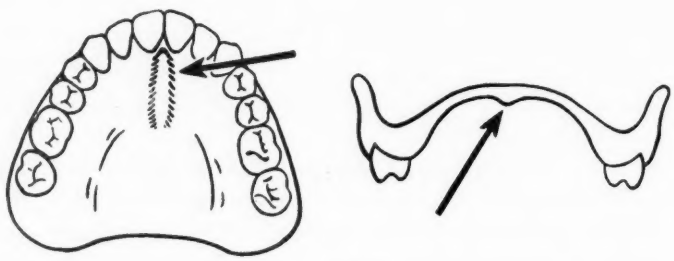

Fig. 3.

The "S" Sound.—The "S" sound is the most common offender in speech difficulties. As a general rule, if the anterior ridge is large, the rugae area should be thin. If the anterior ridge is exceptionally small, the rugae area should be thick. If speech difficulties are encountered, a raised V-shaped ridge running back along the midline from directly between the two upper centrals (Fig. 3) may be first added in wax for a test, and then processed on the denture with cold-cure acrylic. It works like this: If too much space exists between the tongue and the denture base, the midline ridge occludes part of the space. If too little space exists, the ridge provides a tactile reminder to the tongue and that organ withdraws to provide space for the escape of air needed for the "S" sound. Complicated arrangements of artificial rugae seldom improve speech, but a midline ridge frequently eliminates hissing and a slurred "S" sound.

SUMMARY

There is a great need for the interchange of ideas between the dental profession and the dental laboratory craft. The dentist cannot improve his technique if errors are made in the laboratory, because frequently he cannot put his finger some knowledge of the physiologic and biomechanic effects of the appliances he makes. The foregoing observations cover some of the points wherein dental technicians can more accurately translate the dentist's casts and records into more satisfactory full dentures.

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1. Fisher, R. D.: Graphic Interpretation of the Structures Influencing Mandibular Denture Mucoperipheral Outline Form, J.A.D.A. **30**: 408, 1943.

2. Jordan, L. G.: The Arrangement of Artificial Teeth Into Balanced Occlusion. Mimeographed notes for use at the Army Medical Center, Washington, D. C.

United States Naval Dental School
National Naval Medical Center
Bethesda, Md.

News and Notes

ANNOUNCEMENTS

Meeting of the American Association for Cleft Palate Rehabilitation will be held at the Bellevue-Stratford Hotel, Philadelphia, Pa., April 27 and 28, 1951. For any further information, contact Dr. Robert L. Harding, 813 North Second Street, Harrisburg, Pa., Chairman.

The annual Post-College Assembly of the College of Dentistry of the Ohio State University and the dedication of the new dental building will be held May 14 and 15, 1951, at Columbus, Ohio. The General Chairman for this meeting is Dr. V. L. Steffel.

—*Carl O. Boucher, D.D.S.*
Chairman of Publicity